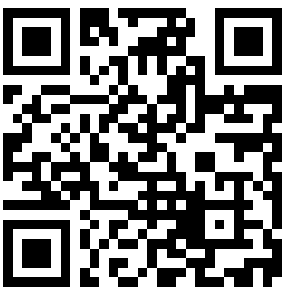
This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google™ books

https://books.google.com



UNIVERSITY OF VIRGINIA LIBRARY
X002129456
Digitized by Google

Fiske Kimball
FINE ARTS LIBRARY

Digitized by Google

Digitized by Google

Fiske Kimball
FINE ARTS LIBRARY

Digitized by Google

Digitized by Google

Digitized by Google

THE

CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

VOLUME TWENTY-SECOND.—1859.

LONDON:
R. GROOMBRIDGE AND SONS, 5, PATERNOSTER ROW.

PRINTED AND PUBLISHED BY WILLIAM KNOTT, FOR THE PROPRIETOR,
AT THE
OFFICE, 13, WARWICK COURT, HOLBORN, W.C.

Digitized by Google

BINDING

Fine Arts
TA
1
.C6
308662
v.22
1859

UNIVERSITY OF VIRGINIA

Digitized by Google

Digitized by Google



Jan.y 1859

J.R. Jobbins.

THE VICARAGE FILLONGLEY NEAR COVENTRY.

Digitized by Google

THE

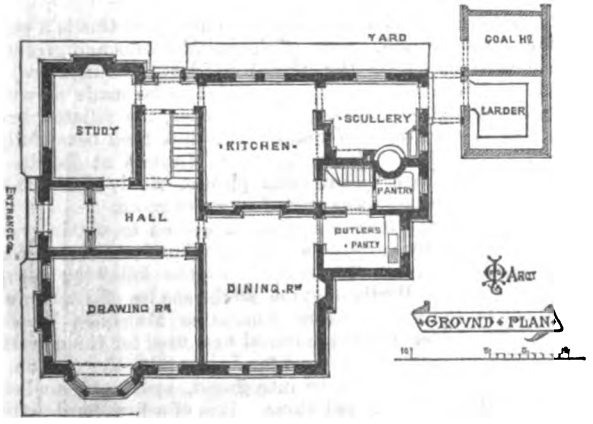
CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

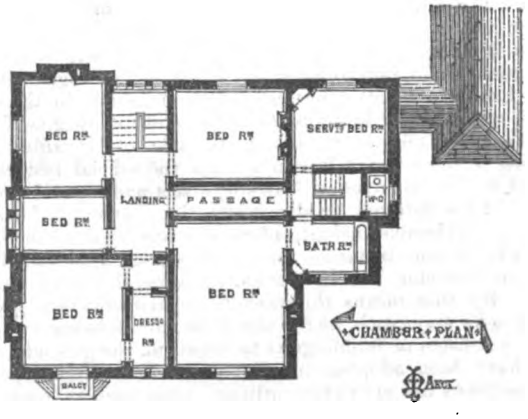
FILLONGLEY VICARAGE, WARWICKSHIRE.

(*With an Engraving.*)

FILLONGLEY is a small village situated between Nuneaton and Coventry, about six miles distant from the latter city. It can boast of a fine old church, which possesses features of Early English, Middle Pointed, and Perpendicular. The structure consists of a wide nave, chancel, and north chancel aisle, with tower of three stages at west end. The old tower, whose two lower stages are Early English, was erected without any staircase; but recently a substantial and characteristic staircase turret of stone has been erected at its north-east external angle, which leads to the ringing chamber, formerly access having been obtained by a ricketty wooden one. The village possesses remains of several half-timbered buildings of Domestic Gothic character. Several alterations and partial restorations have been carried out, but the greatest improvement is the erection of the new vicarage. On the appointment of the new vicar, the old vicarage was found much dilapidated and unsuitable, which necessitated the erection of the one we now illustrate. The accompanying plans and view will be sufficiently explanatory of the structure, with the addition of a few particulars respecting the materials of which it is built.

The walls of the building are constructed of red brick, with bands and checkered work, &c. of black bricks. The cills, plinths, copings, and other stonework of the exterior are of Hollington stone. The roofs are covered with Tamworth brown tiles. All the windows are sash windows; and the fittings generally of the interior, although Gothic, are quite equal to the much sought after Italian in appearance and finish. The floor of the hall is of Minton's tiles. The domestic requirements have received every consideration. The arrangement of the rooms is most convenient and complete: a basement story is under the kitchen department.





The whole of the works have been executed by Messrs. Harrold of Hinckley, for a sum under 1000*l*. Stables, coach-house, and other outbuildings are in course of erection. The architect is Mr. James Murray, of 8, Queen's-road, Regent's-park, London, late of the firm of Pugin and Murray.

Digitized by Google

THE NEW FOREIGN OFFICE, WESTMINSTER.

This great architectural question, which has agitated the public mind equally with that of the profession during the last eighteen months, may now be presumed to be decided by the award of the parliamentary committee, to whose investigation the matter had been referred, in favour of the design of Mr. Gilbert Scott, A.R.A., and which was numbered in the Westminster Hall collection as 116A. The name of the successful competitor may be taken as a guarantee for two things, viz., that the chosen design is in the Gothic style, and that, in carrying it out, the detail will be so studied in all its bearings as to be a worthy exponent of the general conception. It is not our place here to enter into the comparative eligibility of Gothic or Classic for a site in the vicinity of which superior specimens of both styles may be found, nor into the motives which have actuated the last mentioned referees in their adjudication. On this point much has been said and written, as doubtless will be the case for some time, since the partisans of the several premiated competitors, or of some favourite style, will find abundant materials for their purpose in the conflicting opinions of the judges and those of the public at large, not to mention other circumstances which have been commented upon. As the recent decision has however yet to be sanctioned by Parliament, these knotty points will probably be again brought under discussion, and, in a question of such national interest, it is befitting that everything should be placed in its true light, with a view of showing that, under the circumstances, the selection made is the one which, in conformity with preliminary instructions, appears to be best adapted for the purpose, due regard being had to the subjects of arrangement, appearance, and cost.

It is perhaps needless to remark that the new Foreign Office now alluded to constitutes but a portion of a scheme for remodelling the whole of the Government offices, and one, the magnitude of which, if carried out, will completely annihilate the present aspect of all the streets and buildings between Whitehall, the Abbey, and the Park. The entire site would be divided into two nearly equal portions by Parliament-street, and this determines the first line of subdivision in Mr. Scott's block plan, each area thus marked out being, in rough numbers, about 600 feet square. The western half, being the most important, merits the first consideration, and of this the northern portion takes the precedence as being the first to be built upon. For this two designs were submitted—the one presenting an open court, and the other a continuous front towards Parliament-street, the latter being in the author's opinion the preferable treatment. The flank elevations towards Downing-street and Charles-street have each a grand entrance in the centre between the two offices; in the one case, however, this leads into a spacious quadrangle, common to the War and Foreign Offices; in the other, into a smaller one, belonging exclusively to the Foreign Office. Into the questions of the War Office, and the present buildings, it is needless to enter now, as its erection is not contemplated immediately, but in all the arrangements the object has been to combine unity with simplicity in the entire design, with variety in its parts. The position assigned for the new Foreign Office is on the south side of Downing-street (opposite to the present Treasury), and the official residence is allotted to the wing facing Downing-street and a portion of the Park. In the internal arrangements, since some of the rooms require considerable height, advantage has been taken of this to obtain, in some instances, mezzanine stories, approached from the same corridor, but by the aid of a small gallery running above. By this means the various departments are brought within more easy reach, and it also does not necessitate such an undue extension of buildings as to crowd up the ground. High roofs have been adopted in some parts of the buildings, and other portions rise above the ordinary level, such as towers, &c., so that while an agreeable diversity of form is gained, ample accommodation for attendants, besides much spare room, will be available internally. On the ground floor the rooms specified for the Foreign Office are readily provided, but on the first-floor the required space exceeds that below, so that, in one instance, a department has had to be divided by placing two or three of its rooms in a mezzanine over the others. To facilitate communication with these, an extra spiral library staircase is added. The principal staircase to the building is to be in the centre, and it is proposed to be covered by a sort of dome of glass, ornamental in pattern, and occasionally stained in colour.

The design of the exterior is, as we have stated, based upon a simple outline. The principal front is of three stories below the cornice, but with a high-pitched roof rising behind, the monotony of which is relieved by a succession of elegant dormer windows, gabled and crocketted. The centre portion is carried up as a tower above the abutting roofs at the sides, and is covered by a lofty roof, hipping back, continental fashion, all four ways, and surmounted like the others by an enriched metal cresting. The centre portion slightly projects before the general face, and its angles are masked by large octagonal piers, which are continued to the top of the tower, and terminated by the range of the cornice. The only doorway to this front is in its centre, and consists of a bold archway, deeply recessed and moulded, having also a good deal of carving, on each side of which is a corresponding panel-arch of smaller dimensions, and all three are surmounted by crocketted gables. On each side of the central projection the design is uniform, consisting of a series of windows in each stage; the lower being of three lights, and the two upper of two lights each. Every window is placed in a comprising arch, and has the space thus enclosed pierced. On the ground story there is a series of medallions in circular panels between the window heads, and on the first or principal floor the piers between have shafts standing on the string course below, and bearing full length sculptured figures, protected by handsome carved canopies. The third floor has its windows agreeing vertically with the centres of those below; but, being narrower, there is room for a blank panel-arch between each. The outer angles to the flanks are strengthened by solid octagonal piers or turrets, as already described for the centre; these are not finished at the cornice level, but are carried up detaching themselves from the roof, and forming octagonal pinnacles arcaded, and terminated pyramidally.

Considerable attention has been bestowed in the design of the windows generally, and, compared with those of buildings in other styles, they will be found to contain a very unusual proportion of open space. Many of them have 6 feet width of glass, with only one mullion, others have nearly as much without any division. They are arranged to open as ordinary sashes; and, in some instances, there being additional lights in the head, these would open as ventilators by other means. Those windows which may open on to balconies may have French casements, or sashes, as may be preferred. All are intended to be glazed with plate glass in single sheets. The only exceptions to this are the upper parts of the windows on the first-floor of the official residence, which, above the transom, are to be filled with stained glass. The style of the façades is, generally speaking, more columnar and more thoroughly arcuated than has been usual in the modern treatment of the style, the architect considering that this will add greatly to the boldness and effect of the design.

The internal construction is proposed to be fireproof, on a system resembling that prevalent at Paris; but this is a point for further consideration. Some of the metal beams and girders used in the construction (in the official residence for instance) would be exposed to view; these are intended to be made of wrought-iron, and plated with decorations of brass, the foliated brackets under them being also of brass. This has been beautifully contrived in another style in the new Museum at Berlin. The ceilings are to be of ornamental plaster, richly decorated with painting, and the patterns varied in every room.

In the external masonry it is suggested to obtain a certain degree of relief by variety of colour. This is not intended to be very marked, but to be arranged in the following way:—The great mass to be Portland stone, slight shades of difference to be obtained by the use of either Anston or Mansfield Woodhouse stone. The latter was the material first used for the new Houses of Parliament, and it has stood far better than the Anston. The third colour proposed to be introduced, sparingly, to heighten effects, is the Mansfield red stone. It is of a firm hard texture, of a beautiful colour, and very durable. It may be seen in the pavement of the terrace in front of the National Gallery, above Trafalgar-square, where the white stone alternated with it is worn down, while the red remains all but perfect.

Among the more valuable and effective materials intended to be employed are polished red granite, or serpentine, occasionally, for shafts, &c. There will also be considerable beauty derived from the application of inlaid work,—a beautiful species of decoration, but hitherto much neglected in this country. The patterns would be of the three stones above enumerated, but heightened at particular points by polished granite and other

Digitized by Google

materials. Internally, in the grand staircases and official residence, a great deal of Devonshire and Derbyshire marble could be used with advantage, as also alabaster from Derbyshire and elsewhere, under certain circumstances.

In the foregoing description we have entered pretty fully into the chief characteristics of Mr. Scott's design, as submitted in the great competition, and now ultimately selected; it may possibly not be carried out in its integrity, precisely as shown; for the best arranged plan would doubtless be open to improvement on mature investigation; but, whatever modifications may be insisted on, we may rest assured, that, from the able hands into which the building has been entrusted, every appliance which skill and genius can command will be brought under contribution to render the "New Foreign Office" a structure in every way worthy of our country and of our age.

ST. JOHN THE BAPTIST CHURCH, GLASTONBURY.

THE works which have been for nearly two years in progress at this church, are now beginning to promise a speedy termination. Owing to unexpected causes, the time occupied in a comparatively ordinary restoration, as far as the amount of alterations is concerned, has been unusually protracted, but it has enabled the parties to proceed with a care which it could be wished were oftener exercised, both for the sake of old buildings, which are too frequently sacrificed through over hurrying as much as through wilful neglect, and for the sake of the architect, who thus has opportunities of conscientiously investigating the difficulties which he is sure to encounter if he act up to his duty, and then well maturing his scheme of operations.

Externally, but little reparation has been attempted, indeed the building does not require it, for, the masonry being executed in what is unquestionably one of the best local stones (from the quarries at Doulting), it retains a sharpness of arris and substantiality of condition which comparatively few structures of even the Perpendicular age can now boast. The colour, too, imparted by time is a most agreeable one, and the noble church, with its majestic tower (of the true Somersetshire type) is, from all points of view, an interesting and impressive object.

Internally, the whole of the fittings have been cleared out, and are being replaced by new ones of more suitable design, the floors and passages are being relaid, the pulpit and font thoroughly restored, and various architectural features disclosed. Besides this, the roofs have been throughout carefully repaired, and various improvements made in the arrangements of the chancel. Some old altar-tombs between the latter and its north aisle, will be cleaned, but will have to be refixed, owing to the ground (or vaults!) below having partially given way. The slender pier forming the south support of the chancel arch, and which partially receives the thrust of three others, had declined so much from its verticality that it was found necessary to shore up the arches and rebuild it.

THE ROYAL POLYTECHNIC INSTITUTION.

THE managers of this instructive establishment, while preserving for daily inspection a vast amount of permanent attractions, are constantly on the alert in providing extra entertainments, consisting for the most part of lectures and experiments illustrating one or more of the popular subjects of the day, treated in a scientific manner, and yet in a style so comparatively devoid of technicalities, as to be intelligible to all classes of hearers. A highly interesting topic at the present time is discussed and explained on alternate evenings, which is "On artificial light as applied to Photography," practically illustrated by Moule's patent photogenic apparatus, and explained by the professor of chemistry, Mr. E. V. Gardner. The great strides which the art of photography is now making, and its extensive application in a variety of ways, renders the discovery of a substitute for solar light one of extraordinary interest, as increasing to untold degree the facilities for pursuing scientific studies. At present we are not aware that it has been made available for anything beyond taking portraits, but in this it is so successful an auxiliary, that from the specimens we have examined (including one taken in our presence for the purpose of illustrating the process) we may fairly pronounce them equal to those taken by daylight even under the most favourable circumstances. The light possesses an amazing brilliancy, and is specially used by Mr. Moule for the purpose of producing photographic portraits at night or in dull weather. It is generated by burning a compound of antimony, sulphur, and nitre, called "Photogenic composition," the apparatus being designated the "Photogen." It is stated to be perfectly safe in its use, wholly free from sulphurous fumes and like annoyances, and also inexpensive, the cost of the largest size portrait being but about twopence. For theatrical performances, where pyrotechnic compositions are employed, it will doubtless supply a great desideratum. The fact that the process is introduced under the patronage of royalty will of itself be accepted as evidence in its favour, while the patentee, Mr. John Moule, of the Hackney-road, has already secured patents for England, France, and Belgium. The explanatory remarks of the lecturer were all that could be desired, and were evidently appreciated by his audience. Among the earlier lectures is one delivered daily by Mr. King, called "New Inventions Demonstrated." Entertainments such as these merit the widest possible support, and we have much pleasure in recommending them.

In the large gallery may be observed a stand exhibiting a "Foliographic press," a new machine for printing from nature, invented by Mr. G. J. Cox, of Great College-street, Camden-town, which will be found a useful auxiliary to the botanist, and to the architectural carver who culls ideas from the exhaustless resources of nature, inasmuch as, by a very simple method, the exact forms and fibres of leaves, &c., may be transferred to the sketch-book almost instantaneously. The leaf is to be put within the folds of a sheet of prepared carbonised paper, and then subjected to pressure from a roller, by which means it becomes impregnated with ink. It has then only to be shifted on to the intended sheet of paper, which is now to be introduced under a leather flap, and pressed by passing the roller once over the surface, when an accurate result will be obtained.

It would scarcely be worth while to regard with critical eye such transient things as "dissolving views," were it not that they are sure to attract an eager crowd of gazers; it is, therefore, surely desirable, where certain specified objects are professedly delineated, that the representations should be as nearly as possible true to the originals. The subject now depicted is "The Thames" from its source to the Nore; and it naturally presents in its meanderings several architectural scenes. These, it must be confessed, are needlessly incorrect, even allowing the utmost artistic license. To mention only two examples:—The first picture is supposed to show the spot whence the incipient river springs from the earth in the county of Gloucester, but at a distance of very many miles from its capital; and yet Gloucester Cathedral is visible, not exactly in the foreground, but, as it were, in the adjoining field or so, and standing quite *per se!* The other case is the city of Oxford, in which the artist appears to have had a vague idea that its sky line presents a playful variety of tops of steeples and colleges, but nothing more. The only form which can be at all recognised is that of the Radcliffe Library, but the scale to which it is seen is much short of the real one. It would not have been difficult to procure an authentic view, and a thoroughly artistic-looking one too, so that the neglect is the more inexcusable. Such productions tend only to mislead, and are therefore better left alone. Apart from these drawbacks, which we refer to only in a friendly spirit, the several dissolving views may be pronounced successful.

ON THE MANUFACTURE OF THE UCHATIUS CAST-STEEL.*

THE manufacture of cast-steel, of which this paper treats, although not directly in the department of mechanical engineering, is so much connected with it, that a few words on that subject may be interesting to the members of the institution. The quality of the materials used for all parts of machinery and for the tools employed in their construction is of the greatest importance These materials should possess the greatest strength and tenacity, and at the same time a durable and uniform wearing surface. Now cast-steel perhaps beyond all other available metals possesses these qualities, and it is only its great cost that has hitherto prevented its more general application. It has a bearing strength of nearly three times that of best forged iron, and having a per-

* Paper read at the Institution of Mechanical Engineers.

Digitized by Google

fectly uniform texture it wears equally; it must therefore be acknowledged that cast-steel is the best material that can be used where lightness and strength are required, and for all parts of machinery that are subject to much wear and tear. Its great cost being the difficulty in the way of its extended application, the great object in view for some years past has been to find out some process of making cast-steel of a good quality, and at a price that would allow of its free employment. Amongst a great number of metallurgists who have within a very recent period directed their attention to this subject, may be mentioned Bessemer, Chenot, Uchatius, and others. It is intended in this paper to enter only into the details of the Uchatius process of making cast-steel, as compared with the ordinary processes at present in extensive use, which are two,—the English or converting process, and the German or puddling process.

To compare these processes with the Uchatius process about to be described, it must first be considered what steel really is, and in what manner it may be produced. This point may be illustrated by the following series, comprising the various degrees of wrought-iron, steel, and cast-iron, arranged according to the amount of carbon in each, beginning with the softest wrought-iron, that is with the iron containing no carbon or the least amount of carbon:—

Soft wrought-iron, containing		0·0	per cent.	of carbon.
Hard wrought-iron	,,	0·4	,,	,,
Soft steel	,,	0·5	,,	,,
Hard steel	,,	2·4	,,	,,
Cast-iron	,,	2·5	,,	,,
Hard cast-iron	,,	5·0	,,	,,

In this series, beginning with the softest wrought-iron containing little or no carbon, the proportion of carbon increases until there is ½ per cent., which then forms soft steel; a further increase of carbon up to 2½ per cent. forms cast-iron; and the proportion of carbon increasing to 5 per cent. gives the hardest cast-iron. Hence it appears that the operation of steel making may be effected in two methods,—either by adding a certain amount of carbon to pure wrought-iron; or conversely by taking away a certain amount of carbon from cast-iron, removing at the same time the impurities of the cast-iron.

The English or converting process is carried on according to the first of these methods, by adding a certain amount of carbon to wrought-iron. The cast-iron is first made into wrought-iron, which is then converted into steel, forming blister steel; this is broken into small pieces and melted in crucibles, which renders it homogeneous, and is then poured while fluid into ingot moulds, after which it is known as cast-steel. The chemical changes which the cast-iron has undergone in this process are—firstly, when it was manufactured into wrought-iron all or nearly all the carbon was abstracted from it; and secondly, by the converting process a certain amount of carbon was restored to it; and finally, the steel thus produced was made homogeneous by melting and casting. It is evident that this is a very circuitous way of manufacturing cast-steel, and it has the following disadvantages: the great loss of weight in manufacturing the cast-iron into wrought, the difficulty in converting the wrought-iron so as to carbonise it equally in all parts; the great length of time that this process requires for the production of cast-steel, and the great cost of manufacture.

The German or puddling process is effected by the converse method, by taking away a certain amount of carbon from cast-iron. The pig-iron is puddled in the same way as in making wrought-iron, except that the process is stopped when a certain amount of carbon has been taken away, a point which it is difficult to judge of. This partially puddled iron, so-called puddled steel, is then made homogeneous by melting it in crucibles in the ordinary way. The chemical change which the cast-iron has undergone by this process is the abstraction of a portion of the carbon in the puddling furnace; and the puddled steel has then been rendered homogeneous by melting and casting. The disadvantages of this method are: the waste of iron by the puddling process; the uncertainty of getting equally discarbonised iron, owing to the difficulty of measuring the quantity of oxygen acting on the puddled metal; and also the cost of manufacture.

The Uchatius process is based upon the same principle as that last described, consisting in taking away as much carbon only as is required to produce steel, and removing at the same time the impurities of the cast-iron. The first and most important of these objects is effected by bringing a certain measured quantity of oxygen, in the shape of oxides of iron, in contact with the cast-iron, so that while the iron is hot the oxygen combines with the carbon and passes off in the form of carbonic acid gas. The purification of the cast-iron from silica, sulphur, magnesia, &c., is effected by bringing the iron when it is in a melted state into contact with the alkaline earths, so that the impurities combine with them and remain floating on the top of the melted metal.

In order to effect these two operations at the same time the pig-iron is first melted in a furnace or ordinary foundry cupola, and then run into a cold-water tank, where it is reduced into small granules. The mode in which the granulation is performed is stated to be as follows:—the cold-water tank has a horizontal wheel placed in it at one end, provided with wooden floats dipping below the surface of the water, and driven at a considerable speed; the melted metal running into the tank from the furnace falls on the wheel, which scatters it in a finely divided state towards the deep end of the tank, and it falls to the bottom in the form of small granules. This granulated cast-iron is mixed with pulverised oxide of iron and some alkaline earths, and the whole put into the ordinary steel-melting crucibles and placed in the furnaces and brought into a fluid state. The degree of hardness of the steel is thus capable of being regulated by the size of the granules and by the quantity of oxides used.

The chemical change which takes place in the crucible is as follows:—Each granule being surrounded by the pulverised oxides, &c., the decarbonisation takes place first on the outside of each granule, and so progresses towards the centre as the heat increases, the oxygen in the ores combining with the carbon in the granules and passing off as carbonic acid gas; if therefore during the process the granules could be examined, it would be found that the outside of each is entirely deprived of its carbon, the next portion partially decarbonised, and the centre not decarbonised at all; so that each granule would be composed of pure wrought-iron, steel, and cast-iron. By increasing the heat, the cast-iron centre portion of the granule first become fluid, and the granule bursts and falls by its own weight to the bottom of the crucible. At the same time the earths mixed with the ores melt and rise to the top, forming a layer of scoria or dross floating on the surface of the melted iron. Each granule of melted metal has therefore in falling to pass through the rising scoria; and it is in the passing through that the combination of the impurities of the metal with the alkaline earths takes place, so that the decarbonised iron on reaching the bottom of the crucible is cleansed from all impurities. The heat continuing to increase melts the outside portions of the granules, and the whole is reduced to one homogeneous fluid mass in the crucible, which is then ready for being poured into the ingot mould. The iron contained in the oxides mixes at the same time with the fluid mass, and yields about 6 per cent. more of cast-steel than the weight of granules put into the crucible.

The oxides employed in this process are iron ores of the finest quality, such as spathose and hematite, which are previously calcined and pulverised. The proportion of the oxide to the granulated iron is according to the hardness of steel required, say from 20 to 30 per cent.; the greater the quantity of the oxide employed, the greater the decarbonisation, and consequently the softer will be the steel produced.

The process is attended with the following advantages:—A rapid manufacture of cast-steel, the pig-iron being turned into cast-steel in the space of a few hours; certainty in producing a uniform quality of steel, that is steel containing a determinate proportion of carbon, which is accurately determined beforehand by the weight of oxide mixed with the granulated iron; and less cost than the ordinary methods of making cast-steel, since the processes are fewer and the materials used are simply pig-iron and iron ores.

Some experiments in making cast-steel by the Uchatius process have been made by the writer at the Newburn Steel Works, near Newcastle-on-Tyne, from which it appears there is little doubt that a very fine quality of cast-steel can be produced at a cost little more than one half of that entailed by the common processes.

A specimen of steel bar was shown made by the process described in the paper, which had been tested and broke with a load of 30 cwt. at the centre, the bar being 1 inch square and 3 feet in length between the bearings; the deflection was 3⅜ inches at the time of breaking. A specimen was also exhibited showing the welding of two pieces of the steel, and specimens of the granulated iron and the pulverised ore used in the manufacture, and of the bars and plates produced, with some volute springs

Digitized by Google

made from the steel; also a piece of the steel twisted cold to show its toughness.

Mr. T. Spencer said that he had not tested the tensile strength of the steel at present, but found it stood well in the volute springs that had been made of it, which had proved quite satisfactory in working. Only some small plates had been rolled from the steel at present as a trial, but these had proved quite satisfactory; and he did not anticipate any difficulty in making any size required. It would be observed in the specimen exhibited, that the plate was quite sound on the edges, although it had not been rolled edgeways, but simply rolled down lengthways. No wire had yet been made from it; the bars and plates made had been hammered and rolled down from the ingots of cast-steel. The total cost of the finished bars was about one-half of that by the ordinary process; but where the makers hammered and rolled their own steel, and the cost of the ingot only had to be compared, the proportion would be considerably less.

Mr. W. Fairbairn thought this process was a very important step in steel manufacture, and would prove of great advantage in the construction of machinery, if a sound uniform steel could be obtained at a moderate price. The bar of the new cast-steel that was exhibited certainly showed great strength, having sustained nearly three times as great a weight as iron; and he thought in process of time they might reasonably expect to obtain plates cast and rolled of that manufacture at least double the strength of the present wrought-iron boiler-plates for the same thickness, and not much more expensive for the same strength; and it had now become a very important desideratum to get plates for boilers only half the thickness at present used, as the thinner plates were so much less liable to injury from overheating and unsoundness in manufacture.

Mr. T. S. Prideaux thought the dropping of the melted iron into water in the process of granulating it would have a beneficial effect in assisting to free the metal from sulphur, by the metal coming in contact with water in a red-hot state; the plan had been tried in Austria, he believed, with success. It was not at all easy to separate sulphur from iron by simple exposure to oxygen in atmospheric air; and he thought the plunging of the highly-heated granules in water would be the means of removing the sulphur to a considerable extent from the iron.

Mr. W. Smith thought the process that had been tried in Austria was that of Capt. Uchatius now described; the plan of granulation seemed a very ingenious and important step towards obtaining steel by the direct process of decarbonising, and offered the best chance of carrying that process to a successful and economical result. Great advances were being made at the present time in steel manufacture, and they were doubtless greatly indebted for these advances to the investigation of the subject that had been excited by the publication of Mr. Bessemer's plans, although he had not succeeded in all that he had attempted himself; and they were also much indebted to Mr. Binks for having called more minute attention to the chemical principles involved in the manufacture of steel. The new process described in the paper appeared to have effected a great success in obtaining cast-steel by the direct process; and if the uniformity of quality could be maintained, the economy of manufacture would allow of the use of cast-steel being extended to many important new applications, such as boiler plates, and steel wire for the manufacture of telegraph cables.

Mr. A. Lenz explained respecting the process, in the absence of Captain Uchatius, that the only object in dropping the melted iron into water was to effect its granulation, and not for the purpose of depriving it of sulphur. The process of this manufacture of steel was to decarbonise the cast iron by the action of oxides under a high temperature, the great object being to expose the largest possible surface of the iron to this action, and by granulation this object was obtained to a remarkable extent. As to the actual composition of the steel, Capt. Uchatius had come to the conclusion, from the results of his observations, that the best steel required some small portion of what are considered impurities, such as sulphur, silica, &c.; and that chemically pure steel was not the result to be aimed at, and he had found that even with ¼ per cent. of sulphur the steel was of good quality. The great desideratum was to make steel at a very cheap price; and he had hopes it might even be practicable to apply it ultimately to the manufacture of railway bars.

Mr. J. Anderson observed that the first steps had certainly been accomplished towards obtaining a better material at a reduced cost, and this was a very important object to be aimed at. Mr. Binks had been the first to draw attention to the fact of steel containing nitrogen, which from his researches appeared to be an ingredient of great importance in the composition of the different qualities of steel, and he was not aware whether any further information had been obtained upon this point

Mr. E. A. Cowper remarked that, in the list of compounds of carbon and iron given in the paper, the hard cast-iron was put down as having the largest proportion of carbon; but he supposed it was not meant that the hardest cast-iron was that containing the most carbon, as the extreme of soft grey iron was kishy from an excess of carbon. He asked whether the Uchatius process removed the phosphorus from the iron; and what were the results of Chenot's process, by which a spongy mass of iron was produced, which was then compressed and dipped into oil, converted and worked into bars.

Mr. A. Lenz said that only the good qualities of iron were attempted to be used for steel making by the Uchatius process. and the Indian and Swedish iron was principally used, containing very little trace of phosphorus, as it was doubtful whether any phosphorus could be removed in the process.

In Chenot's process the principle was to employ pure magnetic iron ore in powder, which was found in a few situations in the Pyrenees in a natural state of powder, and was separated by a machine from the earths mixed with it. This powder was put into a furnace like a cupola, within a tube in the centre protecting the ore from the fuel, and exposed to a great heat; the powder then became in a spongy state, by reduction to nearly pure iron, but was not able to melt. It was then compressed cold with great force under a hydraulic press to solidify the mass, and was finally carbonised by covering with mixtures of oils and other carbonaceous substances, and melted in a close crucible. He doubted the process being adapted for the actual manufacture of steel on any large scale, and thought it more suitable for the laboratory than the shop; various articles had been made of the steel for trial, which he believed were of a good quality, although he thought there was not any regular manufacture carried on.

Mr. W. Fairbairn had seen the process in operation two years since in Paris, and the steel that was manufactured by that means was of good quality; but the process was carried out only on a small scale, and seemed scarcely suitable for any wholesale manufacture.

Mr. T. Spencer observed that a magnetic machine was employed to separate the iron from the earthy matter, when in the state of powder as found naturally. The pig-iron was broken into 6 or 8 inch pieces, and was at first put into the cupola for melting in the ordinary way; but they had now constructed a furnace for the purpose, as the ordinary cupola rather increased the proportion of sulphur in the metal by absorbing some from the fuel: the new furnace was a kind of reverberatory furnace, melting the iron in a chamber separate from the fire. The fluid metal was then run into the granulating tank; and the granules of iron were collected at the bottom of the tank by drawing off the water

ON THE GEOMETRIC TREATMENT OF SCULPTURE.

By John Bell, Sculptor.

The title of this paper would be accepted as grouping together some considerations of much importance in the association of his art with that of architecture, and on which he would venture to offer a few remarks. They might afford at least a sculptor's view of the subject, which had in that room the best chance of being checked and guided by that of the architect. What, then, might the title "Geometric Treatment of Sculpture" be held to imply? Using the word geometry in its accepted sense, he would submit—that selection of forms and masses founded on lines of geometric contour, as straight, square, circular, elliptical, pyramidal, or wave-like, &c., which especially suit sculpture for the purposes of harmonious decoration. Now although, no doubt, a work of sculpture—as a unit and isolated—is the better for being of a symmetric outline, and well balanced and adjusted in itself as an ornamental form, yet still more was this the case when it was regarded in reference to those situations in which sculpture was usually placed, which also, he conceived, might

* Paper read at the Royal Institute of British Architects.

Digitized by Google

nearly all, more or less, be considered architectural. In a garden, for instance,—those gardens which were suitable for such decorations as vases, statues, or fountains, where there was more or less a symmetric plan, might all in degree be considered as extensions of the house itself to which they were attached—as its outer works, as it were, as affording apartments with walls indeed, but with no roof but the sky. Under this aspect none of such decorations of art as were introduced in these situations were altogether beyond and without the bounds of architecture, but their effect would be influenced in a large degree by the same laws under which they appeared within the immediate courts, halls, and apartments of the edifice itself. When, therefore, a work of sculpture on its pedestal was placed in a garden, the two together, as a mass, would have the best effect if they justly subserved some theory of decorative arrangement, which required in that spot an architectural feature of that quality. He said this in order to acknowledge that even when not directly associated with architecture, it might be very well for sculpture to hold itself bound by the same ties of geometric harmony as if in nearer relation. Of course, when more closely connected with the sister arts—as in statues to fill niches, relievi to occupy panels, figures to become the finials of columns, or extended and diversified compositions to adorn and enhance the tympanum of a façade, or the summit of a triumphal arch—the geometric treatment of the sculpture became more intimately an architectural question. So vital, indeed, did this appear in those cases, as regarded the eventual good effect of both the building that was to be adorned and the sculpture that should adorn it, that there seemed but a remote chance of a happy result unless a geometric laying out of contours and masses, and light and shade, had formed the ground-work of the design. In such cases the most delicate and artistic detail would fail to make up for deficiencies in geometric plot; which latter consideration, however, being regarded, the more beauty of finish the better, as the Athenian had so well illustrated in the exquisite workmanship of those figures which remain to us from the tympana of the Parthenon, which were viewed at an elevation of more than 50 feet. It appeared, therefore, that sculpture should never lose sight of those family ties which bound it to architecture, and by which so much mutual benefit was to be attained. The freedom of sculptural lines, which sculpture drew from the contours and movements of vital forms, might well give flow to the stricter types and masses of architecture; while, on the other hand, the latter, spreading out and aspiring more under the steadfast laws that govern the mineral kingdom, might lend in turn to sculpture the most valuable hints of geometric construction. And that held even in cases where the sculpture was not in direct association with architecture, but was a principle also affecting the art by itself, insomuch that a work of sculpture was ever the most perfect in itself when its general contour possessed that quality and character of geometric symmetry which fitted it for an architectural decoration. In illustration of these remarks, he had selected a few works of ancient and modern sculpture. He had necessarily been limited in his selection; and he had also thought it best to obtain small copies of those works instead of the large originals; and the more so, insomuch as his present theme only related to the general treatment of mass and line, which the reductions before them would serve to illustrate pretty nearly as well as the larger originals, some of which it would have been out of the question to bring there. In those examples, familiar because they were good—like the good tunes in the streets—the eye acknowledged, he fancied, at once the advantages of geometric treatment and balance which they possessed, and in which they advanced the valuable precedents of the best masters. It might, however, be as well to make *in limine* an acknowledgement that to that precedent there were exceptions. In such cases, however, we could not tell how far such examples as did not possess this even adjustment were intended to act as one of a pair; in which case, although when considered as units they did not balance, yet, as parts of a twin decoration they might do so most agreeably,—as was the case with the ears of a sarcophagus, or the handles of a vase, which as units were irregular, yet as a pair regular; and though singly uneven, yet, when justly disposed, were mutually responsive, as was seen in the two side figures of the Medici tomb before them. Had either of those two figures been found separately, or alone, in an ancient ruin, its form would have been deemed irregular; but as they exist now according to the artist's original plan, they were an apt example of geometric and responsive arrangement. He might as well acknowledge, however, that the more he saw of works of art the more vain it appeared to him to attempt to enact perfect canons of taste or treatment. A perfect canon in such matters appeared as impossible in existence as that of a perfect specific in medicine. Thus in this case, although geometric treatment was undoubtedly a part of fine sculpture, and although certain cases of apparent divergence from this rule might be argued away, yet, without pedantry or special pleading, it could not but be allowed that there were some noble works which appeared to play truant to these rules. That remark, however, applied chiefly to figures in the round, in which, in any decided action, it would be recognised at once that a form of geometric symmetry could hardly be obtained in all views. In these cases it would be admitted that that arrangement was the most happy which gifted the front and principal view with the best balanced decorative form. The noble statue of the Belvidere Apollo and the Borghese Diana were in some views of an irregular contour, and yet in others they presented one sufficiently geometric to render them suitable for central forms without a pendant, especially in the centre of an ample space, and comparatively aloof from such lines of architecture as would emphasise their departure from the balanced character of an architectural finial. Although, however, some views of these and some figures might be irregular, yet he conceived that even in these cases the desire was perceptible—to obtain, as much as the subject and action admitted of, a well-balanced and geometric form. Also, with respect to the above-mentioned two statues, we did not know how they were originally placed. The colossal elephantine works of Phidias—the Jupiter at Elis, and the Minerva of the Parthenon—were recorded as having been evenly balanced works; while we were also informed that they were symmetrically placed within the temples that contained them. Without further introduction, he would now advert to two forms of geometric character, to which various of the best works in the round of ancient and modern sculpture appeared to incline. It was on that account, and on account of their simplicity, that he spoke of them especially, and not, of course, with any idea of excluding other geometric resemblances or types. He alluded to the forms of the pyramid and of the vase. These were types which not only moulded the masses and contours of compositions in the round agreeably as sculpture, *per se*, but by the same influence suited them for the purposes of architectural enhancement. In regarding examples of these treatments, however, they must not, of course, expect perfect pyramids or perfect vase forms. The conditions of vital forms were not such as to be confined within limits so rigid; and they could only expect such coincidence as might evidence the plan of their geometric conception. In some works, also, they would perceive the pyramid tall, like an isosceles triangle; in others, flat and spread out, as in the Dying Gladiator, or the exquisite figure of Eve, by Baily, which was before the meeting in small,—a joy for ever as long as sculpture lasted. In one statue or group they might recognise the contours of a tall vase; in another, that of a broad, wide one, as in a seated figure. The proud and expressive group of the "Laocoon" aimed evidently at a pyramidal form, though that was somewhat blown aside by the gust of passion and of pain. The great group of "Circe and the Bull," of which there was a full-sized cast at the Crystal Palace at Sydenham, was on a similar principle, as it was, at some sacrifice, made more or less pyramidal on all four sides. The group of Niobe and her Youngest Daughter, among other works, evidenced an intention towards this form; and in most of them there was a near coincidence with that of a flame of fire, which had ever a tendency towards the pyramid. Milton spoke of Satan, when touched by Ithuriel's spear, as springing up "like a pyramid of fire;" and even the word pyramid was derived from that source. That form was also finely present in the general composition of the tombs of the Medici, as illustrated by the engravings before the meeting, in which, although the facts were so boldly cast about, and so grandly classified, yet that was effectual without disturbing the general geometric arrangement, which was here so finely preserved. He would now pass on to the second form he had indicated as frequent in fine statues and groups—that of the vase—and cite some examples which partook of the general form of a vase-like finial, of which a few familiar examples were before them. The outline and general contour of the far-famed Venus de Medicis afforded, especially in the first view, the general balance of a vase-like finial. The Hercles of Glycon,

Digitized by Google

commonly called the Farnese Hercules, although a figure as far removed as possible from this in character, had a similar quality of arrangement, only it was wider at the foot. Both these statues possessed to a great degree, in their principal view, an evenly balanced vase-like contour. And that quality, no doubt, had a very large part, along with their other merits, in obtaining for them that great popularity which they had ever enjoyed. They were more repeated in ancient art than any other statues: one great cause of this, no doubt, being that, in consequence of their geometric arrangement, they were found so very convenient as architectural decorations; and sculptors might well keep that point in mind when they desired a wide-spread public for their efforts, and tried to work for posterity. The elevated figure of the Phocion, also before the meeting, presented a similar character of contour, illustrating the application of a vase-like outline to a portrait-statue. There was, however, another well-known treasure of ancient art, that still more presented perfection as a vase-like finial—viz., the well-known classic group of Cupid and Psyche embracing, of which a little copy was brought before the meeting. Turn it which way they would, in each view it preserved the just balance, elegant proportions, and general mass of a tall taper vase. In this exquisite and graceful group they possessed a charming example of geometric balance and contour applied to the human form, and of the perfect coincidence of the architectural, decorative, and sculptural element. Although symmetry of form of this character endowed a work of sculpture with a great charm, insomuch that its high value might be received as an axiom, yet occasionally divergence from this might be not only obtainable, but even of great service in emphasising the action and expression of a statue, and that without injuring the effect of its architectural associations. But divergences of contrast were only, he thought, to be looked on as exceptions, and were in all cases to be guided by artistic taste alone, which was more subtle than rules.

Having cited the tomb of Lorenzo de Medici in its whole composition as an instance of the pyramid, he would now apply to the central seated figure, which formed the apex of the composition, for an example of the vase form, drawn together towards the base, swelling out on either side in the centre, and contracting again at the top (as was exemplified in an engraving and a small bronze copy of the Lorenzo on the table). Michael Angelo, being a proficient in all the four arts, was the more open to their combination. In regarding this remarkable tomb, if the spectator would in his mind's eye substitute for the figure of Lorenzo a vase form of similar proportions, and architectural features, or some features of like character, for the recumbent figures on either side, he would perceive how happy was the mere decorative combination as such, even apart from the nobleness of the figures; and, indeed, there were extant previous sketches by Michael Angelo of trials of the arrangement of these figures, in which was evidenced that their architectural arrangement in a geometric manner was his first thought. The Premier Berceau, by Le Bay, of which there was a small copy on the table—that beautiful, wild, melancholy group of Eve and her children, of which conception even the great Florentine himself might have been proud—afforded another charming instance, especially in the front view, of a symmetrical vase form. In the two last instances the vase outline was not tall and tapered, like that presented by the Cupid and Psyche, but was wider and more luxuriant, which was in both cases gained by a seated attitude. It could not be denied that the general contours of both those works were in a high degree just and pleasing, and it appeared to him a great pity that in this country there seemed to be a disinclination to public seated statues in picturesque attitudes. He considered that to be a misfortune to the art of the sculptors at the present time. Seated attitudes were much adopted by the Greeks and Romans, and in later times by the Italians and French; and they had a most satisfactory effect on pedestals in the front of buildings, as would be the case in front of the Royal Exchange and the British Museum. If the authorities especially concerned in the erection of our public statues would first take an architectonic view of the subject, and consider what class of geometric decorative form would be most harmonious in a special site before they determined for a standing or a seated figure, he thought that seated figures would be more frequently executed than they were now, as decorations of this city. The well-known group of the Rape of the Sabines, by John of Bologna, afforded another instance of a vase-like form, round which spiral festoons of flowers might be imagined to be introduced, much as they were in those alabaster vases and flowers which we used as drawing-room decorations. He would now pass on to busts. The ancients frequently made use of the terminal bust, and perhaps that was the most dignified way in which a work of this class could be based; but did not so well subserve the purposes of decoration in our dwellings, and thus, in modern practice, it had been replaced by the bust with the round pedestal. Nollikens introduced, and Chantrey continued this mode of fitting for these works, by which means, especially when placed on the frustra of columns, they became finials, of a vase-like form. Chantrey was very careful in so adjusting his busts that they should preserve a general symmetric form, even at the back, fitting them well for decorations and finials, as might be well, for instance, remarked in the bust by him of William IV., in the centre of the dais at the farther end of the hall in Greenwich Hospital. Mr. Bell next proceeded to offer a few remarks as to the treatment of sculpture in a tympanum. In this feature of art, the general pyramidal form enforced by the space to be filled appeared to be by no means the only consideration. It was unfortunate that they had no absolute record of the precise arrangement of any whole composition of Phidias filling these spaces in the Parthenon; although from such data as remained there was a sort of circular form in the centre, treated in a full manner, and lessening off in waving lines, and inwards the extreme ends might be imagined, as the general geometric treatment entertained. It had been conjectured that the figures of Niobe and her children occupied a tympanum of a temple of Apollo and Diana; but that was not certain. Nor would it be safe to deduce, from a series which had been arbitrarily arranged, the mode of the Greeks in this feature of decoration. We had the arrangement of the Æginatan tympanum; but that was of a crude and archaic character. In illustration of his views of a fine geometric treatment for the sculpture of a tympanum, he was happy to allude to an English design—the beautiful design by Professor Cockerell, which was on the wall. It appeared to him that this charming design afforded a geometric treatment of a rich circular composition in the centre of the space occupied, tangent to the base line, and to the two lines of the roof. That it thus, as it were, supported the apex of the roof, and thence ran off agreeably in diversified lines towards either end. Fancifully, this treatment might be likened to the appearance of a vast mask in the centre of the tympanum, the hair of which flowed off on either side to either end, like that of the "Medusa;" or, travestied by more common ornament, was like that of a coat of arms in the centre, and foliage branching or curling off to the extreme points of the space to be occupied. Another exceedingly picturesque example of the effective filling of a tympanum, and one very familiar, for they could hardly go up Ludgate-hill without seeing it, was in the tympanum of the west front of St Paul's, in the relievo of the "Conversion of St. Paul," sculptured by Francis Bird. It was charming in effect, and one was glad to be able to say, for once, something favourable for London smoke; for the mode in which that had darkened certain parts of this relievo and left others white, had subserved the scheme of the composition, and most vigorously enhanced its chiaroscuro. As regarded the arrangement of sculpture in a tympanum, there was one mode which, he thought, one might safely say should never be adopted—namely, that which would repeat the upright lines of the columns beneath. As regarded the decimation of square spaces, the lecturer mentioned the well-known metopes of the Parthenon cornice, a well-balanced covering of the surface so as to obtain that amount and quality of light and shade that was just for the situations they occupied; but farther than that, any precise adoption of any common geometric line in them was not apparent to him. In the frieze of the same building, especially in the equestrian parts of it—which would be allowed to be the finest example of the kind in existence—a horizontal ribbon-like character of geometric decoration had been adopted; the mass of the relievo, consisting of the bodies of the horses and the lower portions of the riders, formed the centre of this band of decoration, which was shaded off, above and below, with smaller forms—above, by the heads and upper portions of the riders, and below by their feet and the horses' legs. Although all these details were charmingly varied, their continuity as ornament was not broken; nor, although probably the background was made slightly blue, did he believe that anything was done in the way of colouring that was calculated to break up this continuity. The guiding line of this frieze might be said, therefore, to be horizontal, affording an arrangement of men and horses in harmony with the principal architectural lines on the cella immediately connected

Digitized by Google

with it. The lecturer then proceeded to the sculptural treatment of circular forms in relievo, and the geometric arrangement afforded by good examples. He next referred to a very graceful little bronze figure of Sappho, to the statue of the first Napoleon in the Place Vendome, Paris, &c. He next proceeded to consider the character of form suitable to crown a triumphal arch; and, in conclusion, referred to some of the highest works of painting as well as sculpture, as to the evidence they afforded of the dignified and satisfactory results of geometric arrangement in a sister art. He said, that apparently there was no subject that more illustrated the connexion and union of the four arts—architecture, painting, sculpture, and decoration—than the subject of this lecture, insomuch that it might not be inappropriate to conclude with the well-known observation of Michael Angelo, who, when questioned on a collateral subject, replied—"I know but of one art."

THE APPLICATION OF NATURAL FOLIAGE TO ARCHITECTURE.*

By James K. Colling.

The author expressed his regret that at the present time there should be such strong party feeling raging in respect to the different styles in architecture; persons now ranged themselves either upon the side of the Goths or the Greeks—Classic against Gothic; but without going into the merits of either side, he merely premised that in the observations he was about to make he wished to view foliated ornament and architectural enrichment in the broadest and most comprehensive light—to avoid as much as possible the clashing of any styles, or the advocating of one more than another. It was true that ornament received a certain colouring or conventional treatment, according to the style in which it might be used; but the principles and leading lines should be the same in all. The anatomy of the leaves should be alike in every style, although the leaves themselves might be tinged by its peculiarities. All that they could see most to admire in the foliage of the Classic or Gothic eras could be clearly traced to natural forms and natural arrangement; and by studying nature, the fountain head of all true design, had been hitherto followed, they were enabled to improve or vary their ideas, and to take advantage of the other beauties which were sure to spring up before the mind of the diligent student. His remarks were intended to apply to Classic foliage quite as much as to Gothic, and he considered there was far greater room for improvement in modern Classic foliage than in modern Gothic. They went on year after year copying and recopying the old conventional forms of Classic foliage, without attempting or seeming to wish for any change or improvement. They were too much in the habit of looking upon Greek foliage as perfection, and had been contented in merely copying, or at most in recombining and rearranging. If nature were more studied and more adapted to Classical architecture, a vast field of varied and elegant foliated decoration would be soon opened up. They should also at all times take such foliage as was characteristic and belonging to our climate, as the oak, the ivy, the thorn, the maple, and all the beautiful and lowly weeds and plants of our hedges and gardens. In our indigenous flora there was a vast variety and wonderful beauty—beauty of form, beauty of light and shade, and beauty of colour. The forms of leaves alone was in itself a complete and delightful study, yet this was but one portion of the vast page which was opened to us,—there was the study of flowers, some of the most lovely works of our Creator, their form and arrangement, their structure and colour,—the light and shade upon leaves, the moulding as it were of their upper and lower sides, the ramification of their veins, which was very different in different leaves,—the manner of leaves in growing, their colour and ever varying hues, and their harmony with the flowers which grow among them;—all these formed subjects, the study and contemplation of which would be of infinite value to the architect or decorator; his mind would be expanded, his taste refined, and the beauty of nature would be infused into his works. Nothing, however, was further from his intention than to advocate a literal translation of natural leaves and flowers for the purposes of architecture. Natural foliage, however well rendered or cunningly carved, if merely copied from nature, without being translated by the mind of the artist, would fail entirely in its purpose, and would be less effective than the literal copyism of the foliage from any of our architectural precedents. This could not be too strongly insisted upon, because if they told their artists that they should not copy from old examples, but simply say, as it often had been said, that they should "go to nature," they would soon be so deluged with literal representations of natural foliage, that this system of copyism would become worse than the present.

In the rendering of natural into architectural foliage there must be study and thought—life and beauty. It must be the creation of the artist's mind, working upon nature's principles and nature's laws. Flowers and leaves, although so wonderfully various, are to a remarkable degree geometrical and regular in their form and structure. Yet there exists such an extraordinary freedom, that the hard forms of geometry are concealed with an art which alone marks the hand of the Divine Creator and Designer. It is this apparent irregularity and seeming negligence, combined with harmonious colouring and strictly geometrical formation which gives the natural vegetation that charm which so delights us. It is this missing in modern carving of the geometrical and regular as a ground work or skeleton, neglecting nature's first principles, and only aiming at its irregularity, that causes the failure of our otherwise beautiful carving. If we do not commence upon a proper foundation it is of no use arriving at perfection in the art of carving, We are aiming at the shadow and neglecting the substance—producing leaves and flowers before we have arranged the branches. Every flower and every leaf is arranged with such precision and regularity, blended with such marvellous irregularity, that no two flowers or leaves can be found precisely alike, yet all are formed in the most simple and regular manner. Flowers, which radiate from a centre, are arranged upon the triangle, the square, the pentagon, the octagon, and other geometrical forms, and the precision with which this is carried out is very remarkable. Mr. Colling instanced the common white lily, which is formed upon the triangle, and explained its arrangement by a diagram. There were many other flowers which were arranged upon the same principal as the lily, as for instance, the crocus, the snowdrop, the daffodil, the tulip, the wood anemone, the jonquille, and the iris, and it was somewhat remarkable that nearly all these were early spring flowers. He explained a large number of diagrams representing various leaves and trees, and continued to say that these diagrams showed that nature, although ever remaining the same, was always fruitful in change combined with the utmost simplicity—while in modern ornament unfortunately the reverse was the case—there was constantly a want of change with the greatest intricacy. They showed also that nature was regular and geometrical. What could be more in accordance with architecture? They could alter and conventionalise in any manner they pleased. They need not copy, for they could produce changes by substituting leaves of various forms for the simple petals—there they could substitute the triple leaf for the plain petal, or put leaves together after the manner of flowers, as they have seen exemplified in nature, when looking on the top of branches such as the lilac and the maple. Great prejudice existed among many architects against adopting the natural form of a leaf, and they extolled what they chose to call "purely conventional foliage," as being above the natural—although all must be natural that retained any character worth preserving. In the treatment of foliage several things had to be considered—in the first place, the general arrangement of the leading lines, which must be purified from all inelegant forms, and be such as would best harmonise with the architecture that surrounds the composition. Next the material, its texture and colour; and the breadth of form and depth of cutting must be suitable to it. What was suitable and appropriate for a rough-grained stone would not answer for a fine one, and so on. Then the position was to be remembered, and whether the architectural member which the foliage enriched required to be of a flat character or otherwise. What was suitable near the eye must be simplified according to its intended distance or height. Then the light and shade must be studied, which must above all be carefully and duly balanced, while the form of the leaves and foliage required the greatest consideration; and, as among natural leaves and flowers, they found some of the most pleasing and elegant forms which could be conceived, it was perfectly legitimate to take advantage of them. The forms of leaves varied from the most simple to the most complicated—yet, even in the most complicated there was such a simplicity and beauty of arrangement that they could often be altered or adapted in the most happy manner to suit the purposes of the carver, without losing sight of their natural formation.

(*To be continued.*)

* Paper read at the Liverpool Architectural Society.

Digitized by Google

ST. CUTHBERT'S CHURCH, HAWICK, N.B.

The new church just completed at Hawick, at the sole cost of the Duke of Buccleuch, was consecrated by the Bishop of Glasgow on the 16th of November. It is dedicated in honour of St. Cuthbert, the apostle of the district, and is the revival of a church of the same name which existed about the tenth century in the immediate neighbourhood, and in a similar situation. Divine service has not, however, been performed in a consecrated building for the last 170 years; but in 1850, the Duke of Buccleuch erected handsome and large school-rooms, with master's house adjoining, which were so arranged that they could be used for that purpose until a proper edifice should be built. This desideratum has now been accomplished, from a design of Mr. Scott, of London, who has adopted the Early Geometrical style for the characteristics of the building. It consists of nave and aisles under one continuous roof (like the well-known example of Skelton, Yorkshire), a chancel terminated by a circular apse, an organ chamber on the north side, and a vestry. There is no tower, but a bell-cot, which rises over the chancel-arch, and has a crow-stepped gable, as is not unfrequent in the mediæval work of Scotland, has a picturesque effect. The internal admeasurements are as follows:—Nave, 60 feet long, by 19 ft. 6 in. wide; chancel, 33 feet long, by 19 ft. 6 in. wide. The nave piers are circular on plan, with plain square capitals, and the arches are formed of one square order only, with a very bold label. The roof is constructed of trussed rafters without principals. On entering the church, a prominent object is the handsome font, quatrefoil on plan, and having four small marble shafts with carved caps at the angles, and a cover enriched with metal scroll work, &c. The aisle windows encroach upon the roof timbers, in order to gain increased light in the absence of a clerestory. On either side of the chancel-arch are placed the pulpit and an oak lectern. The chancel is elevated two steps above the nave, and is lighted by traceried windows at the side, and by three single-light windows with shafts in their jambs for the apse. Its fittings are of oak. Round the chancel walls is a rich arcade, with small trefoil heads and marble shafts, the caps of the latter being exquisitely carved; the windows are filled with stained glass. The floor is laid with Minton's encaustic tiles, in patterns with the Arbroath stone; and a portion of the chancel roof is enriched with polychrome. An important feature, externally, is the porch; the arched entrance to which consists of three moulded orders, resting upon detached shafts, with a well-carved tympanum, the whole having a bold look of substantiality, united with symmetry of form. The carving has been executed by Mr. J. B. Philip, of London, the metal-work by Messrs. Skidmore and Son, of Coventry, and the polychrome by Mr. Moxon, of Edinburgh.

ON THE NECESSITY OF FURTHER EXPERIMENTS ON FRICTION.

By E. Morris, C.E.*

A long roll of the ablest mechanical philosophers have devoted themselves to illustrating the friction of substances,—from Amontons (1699), through Coulomb (1781), Vince (1785), and Rennie (1829), down to Morin (1831-4).

Although Amontons, De la Hire, and Euler had assumed the co-efficient of rubbing friction between hard bodies (without unguents,) to be usually about $\frac{1}{3}$ of the insistent weight, Rennie and other acknowledged authorities had shown experimentally, that without unguents the rubbing friction between hard metals might "very generally be estimated about $\frac{1}{4}$ of the pressure"—† but this (in Rennie's trials) was with small insistent weights of less than 33 lb. to the superficial inch of contact, and we may here say, that all the mechanical philosophers limited the deductions from their experiments "within the limits of abrasion" —and though Morin showed that all frictions without unguent produced some slight abrasion, this militates not against our generalisation, as under the moderate insistent weights employed in the experiments, that abrasion was necessarily but little—too slight, indeed, to seriously affect results.

Morin's experiments confirmed generally those of Rennie, but the applied weights were not all adequate in magnitude to represent what we now term "railroad frictions."

A reliance upon the results of these philosophers (accurate though they may be within their limited range), led at once to erroneous conclusions, when applied to the heavy frictions of railroads.

A brief illustration of this will suffice:—in 1838, Nicholas Wood published in London a much enlarged and carefully revised and improved edition of his valuable and well-known treatise on railroads; his own experiments therein cited (though made with too small weights) showed $\frac{1}{6}$ to $\frac{1}{16}$ adhesion or bite of the wheels of locomotives upon rails; and this adhesion, it is well known, furnishes the fulcrum for their motion, and absolutely limits their progressive power.

Nevertheless, Mr. Wood in the standard work referred to, finally concluded to assume only $\frac{1}{15}$ of the insistent weight as the effective adhesion of a locomotive clear of that necessary to move itself.

To show the anomalous condition of the science of friction at that day (1838), though more than four years subsequent to the publication of the bulk of the celebrated experiments of Morin, and nine years subsequent to those of Rennie, we may state, as a curious fact, that in the very same year (1838) B. H. Latrobe, C.E., in his famous report upon the location of the Baltimore and Ohio railroad, assumed (as the result of experience here) 1-7·5 as the coefficient representing the effective adhesion of a locomotive engine.

We see, then, that upon opposite sides of the Atlantic ocean, at the same moment of time, two of the highest authorities on railroad subjects (both thoroughly acquainted with the accepted laws of friction) were founding the most vital and important conclusions upon the adhesion of locomotives; and yet the English authority was assuming that adhesion to be only $\frac{1}{15}$ of the weight upon the driving wheels, while our American authority (as the result of actually existing experience here) stated it at 1-7·5, or precisely double. And we may add that Mr. Latrobe was much the nearest right.

At a long subsequent period (1853), Mr. Latrobe found by careful trials at the opening of the mountain division of the Baltimore and Ohio railroad, that the performance of the heaviest class of locomotives with full loads, upon the 105 and 116 feet ascending grades of that well-known railroad, showed an adhesion in actual work of nearly $\frac{1}{3}$. And in support of this we may state, that the working of fully loaded locomotive engines on other roads has now shown conclusively, that at low speeds in the haulage of heavy freight we may fully rely upon an average adhesion of $\frac{1}{4}$ of the weight upon the driving wheels of a locomotive; while under favourable circumstances an adhesion of $\frac{1}{3}$, or even more than $\frac{1}{3}$, will be developed, in defiance of the maximum of friction having been fixed by modern writers at $\frac{1}{6}$.

The late W. R. Casey, C.E., was the first to draw the attention of professional men to the fact that we were largely under-estimating the maximum adhesion of locomotives; and he showed conclusively that even in 1836, Baldwin's and Norris's American locomotives had already realised an adhesion of between $\frac{1}{2}$ and $\frac{1}{3}$ of the weight imposed upon their drivers.

These, and other facts, clearly indicated that the laws of friction, as then accepted by the mechanical world, were inadequate to guide us in the new frictions developed by the application of steam power to railroads; and the uncertainty existing in the minds of even professional men, as to the true coefficient of friction developed by the adhesion of a driving wheel upon a rail, accounts in part for the astonishment with which many engineers witnessed the accession by locomotives of inclined planes previously worked by stationary power, and this uncertainty doubtless had its weight in inducing a leading English engineer (Prof. Vignoles), even so late as 1844, to name 1 in 50, or a gradient of $105\frac{6}{10}$ feet per mile, as the limit of grade which could be practically worked by locomotive power; though at the present day we know that upon the Baltimore and Ohio, and Virginia Central railroads, gradients of 1 in 20, and even 1 in 10, have (temporarily) been successfully surmounted by locomotives with passengers.

For the very important discrepancies which are found between the railroad frictions actually developed by practice, and what they should have been had they followed the laws laid down by Rennie and Morin, the writer has endeavoured to account (without invalidating the labours of either), by remarking that all the experiments upon the friction existing between metals in motion, from which the mechanical philosophers have deduced

* From the 'Journal of the Franklin Institute.'

† Vol. 119, Philos. Trans. 1829, p. 160.

Digitized by Google

their governing laws of friction, were made within the limits of abrasion, and were usually stopped so soon as the metals began to abrade each other—while, on the other hand, all railroad frictions are destructive frictions, or those in which the metals in contact constantly abrade each other.

It will be seen, then, that the ordinary experiments upon friction are inapplicable to some of the most important railroad frictions; and hence there would seem to be a real necessity for further experiments under the actual circumstances which occur on railroads, or at least with such great weights and small surfaces of contact as may more closely assimilate to them.

A somewhat similar view of this subject was taken by the writer in an article in the "Journal of the Franklin Institute" in 1851, in which he argued the probability, that (contrary to the received laws of friction), under great insistent weights and small surfaces of pressure, as between the driving wheels of locomotives and the rails on which they move, there was strong reason to believe that friction increased in some ratio to the surface pressed.

It will be remembered that Rennie and Morin both concur in laying it down as a law, that friction is always "proportional to the pressure," irrespective of the extent of surface pressed or of velocity, and that this is almost universally accepted by the mechanical philosophers of our day (though recent French experiments indicate that velocity should not be neglected); if then it can be established that within the important range of railroad frictions, whether owing to abrasion or any other cause, "friction actually increases in some ratio to the surface," and not wholly irrespective of it (as now taught), important consequences can hardly fail to flow from such conclusion, and the necessity of further experiments to establish the laws of abrading frictions between metals in motion will become apparent.

In his article of 1851 the writer said: "When engines slip their wheels on railways, both wheels and rails abrade, the law of friction changes, and we enter at once upon a new field, in which we have no exact results recorded, and of which we only know that the coefficient of friction is greatly increased."

The writer had frequently computed the adhesion of locomotives from actual loads drawn by them on railways of known grade, and like others had found that the adhesion exhibited far exceeded the extreme limit of $\frac{1}{6}$, laid down as the maximum by Rennie and Morin; and he had also noticed that fully loaded locomotives, in passing from broad to narrow rails, invariably slipped their wheels upon striking the narrow rail; and hence, in the article of 1851, he inferred that the adoption of rails of the top width of the available wheel-tread (say 4 inches) would largely augment the ascensive power of locomotives on high gradients. Since then a striking fact has been made known, which seems to confirm, in a conclusive manner, the accuracy of the views then taken on this important point in railroad affairs.

The fact referred to has been developed in the working of the Mine Hill and Schuylkill Haven Railway, a heavy coal-road; the chief engineer of this work, R. A. Wilder, states, that upon his road a 92-feet grade laid with narrow-topped rails is immediately succeeded by a 130-feet gradient, on which rails of full width are placed, and in the working of this road with heavy coal-trains "it is found that an engine can draw more (ascending) upon the 130 than on the 92 feet grade, although the actual resistances on the former grade are full 33 per cent. greater than on the latter." We quote here the words of Zerah Colburn, C.E., and we think he might fairly have estimated the resistances upon the 130-feet grade as being full 40 per cent. over those of the 92-feet gradient, since gravity alone upon the former would amount to 55 lb., and on the latter to only 39 lb. per ton of 2240.

In observing various of the frictions connected with railroads, the writer has been irresistibly led to the conclusion that friction between metals, under heavy weights, must increase in some ratio to the surface pressed, or to the weight imposed, or to the velocity, or in combined ratio of the three;* and he is glad to find that many intelligible mechanics (struck by the anomalous results of our present theory of rubbing friction, when great weights or severe pressures are in action), are beginning to entertain similar views.

It is a singular fact that one of the series of Rennie's experiments (table viii. p. 159, 119th vol. Philos. Transac. 1829), although evidently regarded as anomalous by him, nevertheless sustain fully, as far as they go, some of the views above expressed; made under much heavier weights, in proportion to the surface pressed, than in Rennie's other experiments, and pushed in some instances up to or beyond the limits of abrasion; they represent more nearly the conditions of railroad frictions, and they give far higher coefficients for the friction of iron on iron without unguents, than any other of Rennie's experiment; these coefficients augmenting with the weights imposed, varying from 1-2·4 to $\frac{1}{4}$, and averaging $\frac{1}{3}$. Nevertheless, Mr. Rennie in his general conclusions, while deducing the laws of friction from his experiments, passed almost unnoticed over this remarkable table (No. viii.), and assumed the rubbing friction between hard metals without unguents, as being only $\frac{1}{8}$, whilst in no single instance of iron on iron recorded in that table was the coefficient of friction less than $\frac{1}{4}$th.

In the trials recorded in this table (No. viii.), the insistent weights varied from 186 to 560 lb. per square inch, and the coefficients of friction with the same surface in action (6 square inches), constantly augmented with the weights from $\frac{1}{4}$ with the former, to 1-2·4 with the latter pressure. So that it may ultimately prove that a correct formula for friction in such cases may have to involve both weight and surface, and perhaps also time and velocity, instead of being in ratio of the weight alone, irrespective of time, surface, or velocity, as laid down by Rennie and Morin.

But even the highest pressures used by any of the experimentalists are but small when compared with those imposed in the working of railways upon the driving-wheels of locomotives, on each of which 4 tons in this country, and 6 tons in England, are common weights.

Now if, in consequence of unavoidable deflections in the track, we admit that the practical bearing of a locomotive wheel upon a rail may be so much as $\frac{1}{2} \times 2$ inches., we have only one square inch of surface of iron to resist an imposed weight of from 8960 to 13,440 lb.

No such weights per superficial inch have ever been used by the mechanical philosophers in their general experiments upon friction, and therefore none of these can fairly be said to represent the conditions of railroad frictions; for in these frictions the comparatively enormous weights applied render abrasion certain and unceasing, while in deducing the general laws of friction, the experiments which involved material abrasion have been uniformly set aside.

Mr. Casey, in the article before quoted, has shown that it is quite probable the adhesion of locomotives in certain cases has even exceeded $\frac{1}{3}$, and every engineer knows that it very often far exceeds $\frac{1}{6}$, though the latter is the maximum coefficient allowed by those experimentalists who are now recognised as being the highest authorities upon the laws of friction; further experiments are therefore unquestionably necessary to settle this important point in the science of mechanics, and it is to be hoped that they may soon be undertaken upon a suitable scale.

Although Rennie and Morin (on whose experiments the usually accepted laws of friction are mainly based) decided unequivocally that the coefficient of friction depended solely upon the pressure, "without regard to surface, time, or velocity;" nevertheless, an earlier philosopher (Dr. Vince), whose experiments were well known to both, had shown (vol. lxxv., Philos. Transac., p. 175), that "the friction of a body does not continue the same when it has different surfaces applied to the plane on which it moves, but that the smallest surface will have the least friction," and this is to be understood as within the limits of abrasion.

Notwithstanding Dr. Vince's conclusions have usually been disregarded by modern philosophers, upon the ground that his experiments were on a scale too limited to establish mechanical laws; nevertheless, it would appear quite probable, that under certain circumstances the deductions of Dr. Vince may be found the most correct, as scarcely any branch of mechanical science is based upon experiments so anomalous in their character as those from which the usually received laws of friction have been inferred by a generalisation evidently forced.

Nor is this observation too strong when we recollect that Rennie, after showing by table No. viii. of his paper, that iron on iron without unguents, and with only ordinary pressure, had a friction of over $\frac{1}{3}$, yet finally adopted a fractional coefficient for this very case of only $\frac{1}{6}$th.

Morin in another case, that of hard wood with unguents (to which we shall again refer), adopted 1-6·2 as the coefficient of the

* Prof. Renwick (1832) recognised the necessity of this, and proposed a formula, embodying pressure, surface, and velocity. See Renwick's Mechanics, p. 120.

Digitized by Google

friction of rest, and 1-13·7 as that of motion; whilst the experiments made upon a large scale by a committee of the Franklin Institute, showed that these coefficients were in reality less than half as great as those announced by Morin.

The writer will now refer more particularly to some striking anomalies in the friction of heavy weights on wood, with unguents, which are remarkable as indicating the inaccuracy of some of Morin's coefficients, when applied on a great scale to heavy masses in motion upon lubricated wood.

In a report by a committe of the Franklin Institute on the coefficients of friction developed at the launching of the U.S. war vessels, the Raritan and the Princeton, they show conclusively that the friction of rest of these vessels upon wooden ways, well lubricated with tallow, was about $\frac{1}{16}$, while the friction of motion was about $\frac{1}{30}$. Now, Morin (as above stated) gives a coefficient nearly as high as $\frac{1}{8}$ for the former and $\frac{1}{14}$ for the latter; the differences being over 100 per cent. Had Morin been correct, these vessels would not have launched at all, instead of moving off as they did of themselves the moment the stay blocks were sawn asunder.

The Raritan was estimated to weigh 1200 tons, and her pressure on the ways was 3560 lb. per square foot, while the Princeton weighed 577 tons, and had a pressure on her launching ways of 2280 lb. to the superficial foot.

These conclusions of the Franklin Institute, notwithstanding their extraordinary variance from the coefficients of Morin, are in close accordance with similar experiments in England and France, as quoted by Rennie (vol. cxix. Philos. Transac., p. 155), where the Salisbury, a frigate of 58 guns, with a pressure of 6336 lb. per square foot upon her launching ways, and soft soap for the lubric, had a coefficient of friction of $\frac{1}{26}$,—while for similar cases, with hogs'-lard for the unguent, and a pressure of 7056 lb. per square foot, Coulomb made the coefficient of friction $\frac{1}{17}$, and with tallow Coulomb made this coefficient $\frac{1}{28}$.*

We may therefore conclude, that whether with hard metals without unguents, or with hard woods lubricated with the usual lubrics—as in the adhesion of locomotives in the former, or in the launching of men-of-war in the latter case—Morin's coefficients of friction are entirely inadequate to represent the facts, being in the case of adhesion but half as great as practice indicates; while in that of launching ships they err the other way, being twice too large.

It is quite probable that the recent extraordinary difficulties attending the famous launch of the Leviathan, arose from an under-estimate of the friction of abrading surfaces of iron, of which the coefficient under the circumstances doubtless exceeded $\frac{1}{8}$, while if our recent books were relied on, it would have been assumed at $\frac{1}{6}$,—a difference great enough in such a vast weight to have created all the difficulty and extra cost which attended that celebrated launch, and called forth all the resources of the distinguished engineer in charge.

We can hardly therefore avoid the conclusion, that the laws of friction as now received, if applied to the heavy pressures often used, are entirely inadequate, and that further experiments are necessary to the correct solution of many practical problems.

Should any such be undertaken, the writer would suggest that a long inclined plane be used, and great sliding weights, so as to assimilate the case to that of launching ships—then by an automatic contrivance, such as was devised by that able mechanic, Joseph Saxton, and used by the committee of the Franklin Institute at the launches of the Raritan and Princeton, the exact motion of the body under trial, in seconds, or parts of seconds, could be correctly marked upon a tape, and the following simple formula will determine the coefficient of the friction of motion of rest (by taking the space described in the first, second, or half second), or of both combined.

The following note to the report of the committee on the launches exhibits a simple formula for determining the friction of the inclined planes, as well as a graphic mode of representing the inclination of the plane of the friction of motion, or angle of friction:

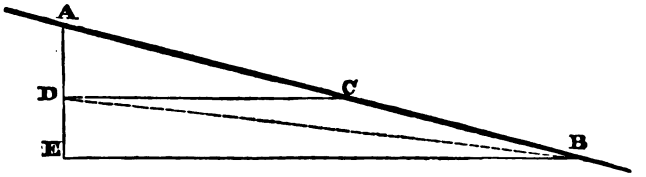
"Another method of considering the subject of friction upon inclined planes has been suggested by a member of the committee, which results in a formula different from that we have employed.

Thus calling AC=S, the space actually slid over in a given time, t, by any body descending an inclined plane.

AB=S′ the space which the body would have described by theory in the given time, $t=\frac{1}{2}gt^2 \sin. i$, friction being null.

ABE=i, the angle of inclination which the plane forms with the horizon.

DBE=f, the angle of friction due to the body in motion.



"Then AE being the total vertical space through which the body would have fallen in the given time t, if friction had not existed; and AD being the actual vertical space fallen through in the given time t, it follows that DE represents the retardation due to the friction of the body upon the plane AB. DBE will be the angle of friction of the body, and $\frac{DE}{BE}$ will be the tangent of the angle f, or coefficient of the friction of motion pertaining to that body.

"Knowing then simply the actual time occupied by the sliding body in descending any measured distance along the plane, the formula for finding the coefficient of its friction will be

$$\text{Tan. } f = \text{Tan. } i \left(\frac{S'-S}{S'}\right)$$

which represents all the resistances encountered by the moving body.

"By this formula the angle of friction of the Raritan frigate, computed from a time of 11 seconds, occupied in sliding 59 feet upon a slip of 3° 40′ slope, is 1° 55′, the coefficient of friction or natural tangent of that angle being ·0336, or nearly 1-30th.

"The angle of friction of the Princeton steamer, computed by the same formula, from a time of 5½ seconds, occupied in sliding 19·62 feet upon a slip of 4° 25′ slope, is 1° 53′, the coefficient of friction or natural tangent of that angle being ·0328, or rather more than 1-30th.

"The mean of these two results gives an angle of friction for launching such vessels as these of 1° 54′, or a coefficient of friction of very nearly 1-30th."

So that the angle of the friction of motion in launching men-of-war may be fairly assumed at 2°, and the proper declivity of the launching ways at 4°.

The old experiments on friction made in the last century by Coulomb, Vince, and Ximenes,* have been lightly laid aside by more recent philosophers, but they seem in fact to be much more applicable to practical affairs than the more elaborate experiments of Rennie and Morin.

* See Renwick's Mechanics.

THE EXHIBITION OF THE ARCHITECTURAL PHOTOGRAPHIC ASSOCIATION.

THE second annual exhibition of the works offered for selection to subscribers is now open at the Old Water-Colour Gallery, 5A, Pall Mall East. The collection is not as yet quite complete, some Spanish views, which are expected, not having arrived; but it numbers now 379 subjects, from twelve contributors, most of whose names are familiar to the art-world. Some of the works have been taken expressly for the Association, and we may mention at once, as perhaps as interesting a series as any in the room, those produced under these circumstances by Mr. Bedford. Making some allowance for the freshness of tone and clearness of detail which recent photographs usually possess, there is a charm about these which only a skilful artist and manipulator could impart. They are chiefly views of Tintern Abbey—one of the loveliest ruins in England, and in one of the loveliest spots. Besides these there are two or three of Raglan Castle, and two of Chepstow. Of a former series (exhibited in 1857) there are some reproductions; they are, almost without exception, good, but show that the art has since made considerable advances.

* For an excellent summary of these see Renwick's Mechanics.

Digitized by Google

The most liberal contributor is Macpherson, of Rome, who sends 120 works, a large proportion of which are architectural in their character, and the whole are, we believe, Italian scenes. Many of these might be singled out: one of the cleverest is (14) "the Castle and Bridge of St. Angelo, Rome," in which art and nature are happily combined. There are several views of St. Peter's, but none of particular interest; also two of the "Columns remaining of the Temple of Jupiter Stator" (72 and 79), and one of the noble Coliseum (74). A fine view of the "principal doorway of the Church of Sta. Maria at Toscanella" (30) must not be overlooked, nor some excellent reproductions of various bas-reliefs from the triumphal arch of Titus, and the Antonine column in the garden of the Vatican.

As may be imagined, Venice is not unrepresented, but there are not many novelties; indeed it would be difficult to find any portion of the "city of the sea" which, if worth doing at all, has not been done over and over again—the Doge's palace in particular, and the Church of St. Mark. However, the majestic "Bronze Horses" of the latter (133), and the "Sitting" (131) and "Recumbent" (135) "Lions of the Arsenal" are really fine specimens of sculpture, and, as such, are worthy of a place here, though, perhaps, they would not be so attractive in an ordinary picture-frame.

Recurring again to English scenery, we have, from (157) to (184) some photographs by Cade, of Ipswich, principally of Cambridge colleges, in which the scale is too small to admit of expressing more than their general features. The two neighbouring priories of St. Botolph, Colchester, and St. Osyth (the latter once the residence of Bishop Bonner), are worthily transferred in (173, 174, 177); while the beautiful church of Southwold, one of the most perfect specimens of flint-ornamentation existing, is shown in (180); and the ruins of Walberswick Church, which are in the immediate vicinity, in (179).

Great variety is given to the character of the exhibition by the extensive field in which photographic artists are now labouring, and the consequent diversity in the subjects that come under their observation. We have already referred to some of the phases of architectural art in this country, in Italy, and in Venice; our catalogue now conducts us to Egypt, and presents us with an instructive series of illustrations by Robertson and Beato, of Cairo. Of the majority of these we can only say that their small size renders it quite impossible to convey a satisfactory impression of ponderous and stately piles. This is the more perceptible, inasmuch as some large photographs which have recently been imported from Egypt are among the grandest and most successful achievements in this line; and some others on these walls, by Frith, are deserving of high praise.

The Spanish views, by Lousada, will be examined with interest, also the French series (though few), by Baldus, of Paris. Among the latter we would call attention to the beauty of (268), "the Steeple of St. Pierre, Caen."

On the whole this exhibition is well deserving of a visit, not merely from those who, as subscribers, are personally interested in the matter, but from the public at large, since improvements in photography have now been carried to that extent that, in an artistic as well as instructive point of view, in collections such as this there must necessarily be much to delight. It stands too, at this season, almost *per se* of its class, now that the Architectural Exhibition is no longer a winter one; and the reasonable terms (half-a-crown each) on which "season tickets" are procurable should be a further stimulus to encourage the institution. The *single* charge for admission is a shilling, but to subscribers it is free. Besides being open daily from nine to dusk, the rooms are lighted on the evenings of Tuesday and Thursday from seven to ten, to enable those to see the collection who may be precluded from attending in the day-time.

THE NEW ADELPHI THEATRE.

The new Adelphi Theatre, with the exception of the enlargements which have been made, stands on the same site as the old. By excavating the pit to the level of the Strand pavement, instead of having it, as formerly, more than 10 feet above it, and by carrying the roof a little higher, an addition of some 25 feet is gained in the clear height of the interior, and this important enlargement is at once manifest in the lofty and imposing effect of the tiers of boxes. The wall on the western side, though rebuilt, is in the same position as that which it replaced, but the eastern wall has been moved some 30 feet further away, so that, in fact, the area of the interior has been very nearly doubled. Thus, the width between the boxes is now 44 feet, 6 feet wider than the Lyceum, and nearly 12 feet wider than the Olympic theatre. The total length of the whole of the new building is about 110 feet by 70, almost the largest minor theatre in London, and this space is so carefully and judiciously broken that the idea of space is entirely removed, and the audience see only a series of most graceful curves marking the line of boxes, and the fronts of which are so decorated as to make them the richest and most effective portions of its internal architecture.

The old entrance from the Strand still remains, and through this the audience pass at once to the level of the pit, which is nearly twice the size of the old one. The part nearest the orchestra is railed off for three rows of orchestra stalls, each seat in which is an ample and well-padded armchair, and gives the same dimensions for perfect comfort to the occupant as is afforded by the pit-stalls at Covent-garden. Behind these are four rows of pit-stalls. Above the pit is the first tier of boxes, which projects 6 feet beyond the iron columns which carry the other tiers. In this balcony are two rows of seats, each 1 ft. 10 in. wide by 16 in. deep, with the backs sloping 4½ inches instead of 2 inches. The front of this balcony is a light and exquisitely wrought iron railing decorated with white and gold, and with interstices sufficiently wide to allow the varied colours of the ladies' dresses to be plainly seen. Behind the balcony, on a level as to projection with the tiers above, is a row of public or private boxes. Beautiful spiral cast-iron columns, with elaborate capitals in white and gold, support the upper tier. The front of this is enriched with white and gold decorations, with panels in bas-relief representing the figures of the Muses. The sitting accommodation here is equal that in the stalls below. Above this, and supported by the same kind of columns, is the gallery tier for gallery stalls. The front of this tier is also exceedingly handsome, and adorned in panels with medallion portraits of dramatic authors. Behind this is the gallery proper, with the usual side galleries, every part being constructed with the same regard to comfort and a good view of the stage. In order to secure the latter important object a point of the stage 35 feet from the front was taken as the centre; and from this the seats were ranged, so that the radius of each is unbroken by any obstacle. The ceiling is in what may be called the Genoese style, but the admirable effect of Mr. Sang's decorations impart a lofty dome-like aspect to it, which enhances the appearance of the whole interior. Looking from the pit, it is difficult to believe that the ceiling is not a high dome. On the west side of the proscenium is the Queen's box, on the east that of the Prince of Wales. Each of these is as large as a well-sized modern drawing-room, and the richness of their appearance is increased by the fronts having balustrades of the most brilliant cut glass. The effect of this handsome but novel style of decoration will be beautiful; the execution has been entrusted to Messrs. Defries and Sons, whose artistic labours in glass manufacture have done so much to enhance the beauty of our London theatres. The whole of the proscenium, and the ceiling immediately over it, is covered with bold yet delicate traceries in white and gold, which preserve the beauty of detail without detracting from the harmony of the whole. The proscenium itself is 38 feet high by 35 feet wide—several feet larger each way than the proscenium of either the Lyceum, Olympic, or Princess's. The whole theatre has sitting seats for 1500 persons, but this estimate allows such ample accommodation for each that one may fairly say the new building will accommodate 2000 with far greater comfort to themselves than ever the old one did one-half of that number. The mode of lighting is simple but brilliant in the extreme, the whole building being illuminated from the ceiling with one of Stroud's patent sunlights. The light itself is concealed, though its effect is increased by an exquisitely formed chandelier—a glittering mass of cut glass coronets, prismatic feathers, lustres, spangles, and which has also been designed and furnished by Defries and Sons, and reflects the highest credit on their taste and skill.

The whole theatre from pit to ceiling is fire-proof, and in case of a chance or mischievous alarm of fire so many exits are provided into Bull-inn-court, and from the back of the stage to Maiden-lane, that the whole audience could quit the building almost instantly. The architect is Mr. T. H. Wyatt.

Digitized by Google

THE WESTMINSTER CRIMEAN MONUMENT.

In a former number we mentioned that preparations were being made for the foundation of a memorial column in honour of Lord Raglan and the "Old Westminsters" who fell in the Crimea. The whole cost is to be defrayed by their schoolfellows, and the site chosen is a felicitous one, viz., the intersection of the centre line of the archway into Dean's Yard (leading to Westminster School) with that of the longitudinal axis of the Abbey, and therefore directly facing its great west door, in the open space of the Broad Sanctuary. The memorial consists of a column of Peterhead granite, banded in the middle with a cable-moulding, from which depend a series of shields, appropriately charged. This column stands on an octagonal pedestal, which, with the whole of the remainder of the work, is of Portland stone. On the cardinal faces will be the several inscriptions, while the alternate faces have square piers with enriched capitals abutting against them, and supporting each a recumbent lion. A flight of octagonal steps, on the lower of which is a handsome iron railing, completes the lower part of the design. The capital to the column is somewhat of the Corinthian type, bearing a square abacus, with the corners notched back so as to form a kind of plinth for four canopied and gabled niches, in which are represented, each in a sitting attitude, King Henry III., Edward I., Queen Elizabeth, and Queen Victoria. Behind these niches rises a square pedestal, on which stands a bold group of St. George and the Dragon, which forms the crowning feature.

The dimensions are as follows:—Total height, 62 feet; height of shaft, 27 ft. 6 in.; diameters of shaft, 3 ft. 6 in. and 2 ft. 11 in.; height of base, 14 ft. 3 in.; and width of base 10 feet. The architect is Mr. Gilbert Scott, of Spring-gardens, London, and the sculptor, Mr. J. Birnie Philip, of Vauxhall-bridge-road. The large upper group is to be modelled by Mr. J. R. Clayton.

The foundation stone was laid on the 10th ult., by the Rev. C. B. Scott, the head master of Westminster School, in the presence of a goodly muster of past and present school-boys. A brass plate was introduced into the stone, bearing an appropriate Latin inscription, which we here transcribe:

M . S .
IX . VIRORVM .
DOMINI . DE . RAGLAN . G.C.B.
F. MARKHAM . C.B.
A. S. WILLETT . F. H. DYMOCK .
W. W. JORDAN . R. H. SOMERVILLE .
R. BOROUGH . C. MADAN .
F. HENTY .
APVD . HAS . ÆDES . OLIM . INSTITVTORVM .
QVI . SVO . QVISQVE . ORDINE .
AD . CHERSONESVM . TAVRICAM .
PRO . PATRIA . HONESTE . OBIERVNT .
HVNC . LAPIDEM .
VIRTVTIS.
PRÆTERITÆ . TESTEM . FVTVRÆ . INCITAMENTVM .
PECVNIA . COLLATA . POSVERVNT .
CONDISCIPVLI . ATQVE . OPPIDANI .
OLIM . WESTMONASTERIENSES .
A.D. MDCCCLIIX .
DEFVNCTI . ADHVC . LOQVVNTVR .

G. G. SCOTT, A.R.A. ARCHT.

THE BAROMETER AS AN ENGINEERING INSTRUMENT.*

By John M. Richardson.

It is firmly believed that a proper use of the barometer in all reconnoissances will lessen the number of experimental lines usually surveyed, facilitate the location of the road or canal, hasten its construction, and thus confer a benefit upon the public.

Before setting any survey on foot, it is the usual custom for the chief to pass over the proposed line and examine it with the eye alone, selecting "guiding" or "ruling" points through which the road must pass, and gaining all possible information with regard to the country from the inhabitants along the route. The knowledge thus obtained is of great importance, and its benefit is felt when the more careful and accurate observers, the level and chain, follow after, noting with the utmost minuteness every change of grade. But the eye is a very unsafe engineering instrument, and should not be too implicitly relied upon when used without the aids which science and art have given it. It is true that by long practice, some can judge pretty correctly as to the distance of two objects apart, or as to their relative difference of level so long as they both remain in sight: but when space, and forests, and mountains intervene between two stations, A and B—especially if their be a succession of ascents and descents between the two—an engineer, aided by the eye alone, cannot say with any certainty when he has arrived at B, "I am below A," or "I am above A," except in one case, viz., when he has been following the course of a stream.

The use of the barometer will prevent the occurrence of any such errors, and it is probable that they are numerous. By it the level of one gap in the range of hills or chain of mountains can be compared with that of another, and thus the comparative ease or difficulty of connecting the contiguous plains or valleys by passing through one or the other, ascertained in the shortest possible time and with the least expense. If merely examined *par un coup d'œil* in the reconnoissance, experimental lines must be run through both gaps, and the two routes can only be compared, their relative merits and demerits ascertained, after a long, laborious, and expensive instrumental survey.

By using the barometer, the chief after his reconnoissance can say, with almost absolute certainty in any case, which terminus is above the other, which is the highest point along the route, which the lowest, and where the greatest difficulties are to be encountered. The barometer does not indeed give horizontal distances, but in determining the practicability of any proposed route they are of subordinate importance compared with differences of elevation. A pedestrian, a carriage, a locomotive, can accomplish horizontal distances with ease, but they cannot so easily ascend and descend hills and mountains. "These are the chief obstacles to the construction of roads and canals, and are the natural enemies of the engineer." By using the barometer he does not lessen their hostility to his improvements, but he discovers in the most expeditious manner where they are weakest, and where he can best attack and most easily evercome them. This is all that is claimed for the barometer as an engineering instrument; and it is enough. Its results are not so correct as those of the level. They are only approximations. It goes before, and, as it were, sketches out the work—gives the outline; the level follows after and completes the picture. But by means of the sketch which the barometer furnishes the level, the latter is enabled to accomplish its work in much less time, and at a vastly diminished expense. Up to the present time the barometer has been chiefly used by travellers in determining the approximate altitudes of mountains, by chemists in ascertaining the specific gravity of gases, and by mariners as a weather glass. Its utility as an engineering instrument has been recognised practically but by few, either in this country or in England; on the continent of Europe it has been (such is the writer's information) more extensively employed.

The recent "Pacific Railroad Surveys," instituted and carried out by the general government, have been instrumental in calling the attention of engineers more particularly to the barometer, and have demonstrated beyond the shadow of a doubt, its great value as an engineering instrument, particularly where the reconnoissance extends over long lines, and where there are, anywhere along the line, considerable changes of level.

The reports of the surveys alluded to, and more particularly that of Lieut. Williamson, afford much valuable information on this subject. Lieut. W., as already quoted, states that the profiles "determined by the spirit level and barometer agreed remarkably well." This is important as bearing upon the relative accuracy of the level and barometer.

The following determinations of the height of Black Mountain in North Carolina, have been going the rounds of the newspapers, and are presumed to be correct.

Barometer	6708 feet	Prof. Mitchell,	1855.
,,	6709 ,,	,, Guzot,	1856.
Level	6711 ,,	Major Turner,	1857.

(Mean of barometers 6708·5); difference +2·5; per cent. +·000372.

$$H = 1{\cdot}000372\,h, \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Combining with (9),

$$H = 1{\cdot}003178\,h, \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

* From the 'Journal of the Franklin Institute.'

Digitized by Google

If the above reputed measurements of the altitude of Black Mountain are the ones determined by the gentlemen whose names are attached to them, formula (10) is valuable.

The results are remarkable, and, as bearing upon the relative accuracy of level and barometer, important. The altitude of the mountain was determined by means of the barometer at two different times by two different observers, and probably with two different instruments. The results differ by 1 foot. The third determination was made by means of the Y-level, by a third observer, and at a different time. It exceeds the loss of the previous determinations by 3 feet, the greater by 2 feet, and their mean by 2½ feet. The names of the observers are a sufficient guarantee that every precaution was taken to insure the greatest possible accuracy.

A few such independent determinations of the altitude of the same point are of more value perhaps than a number of isolated observations made to determine the altitudes of different points by the same individual with the same instrument. And if scientific men, who have opportunity, will only multiply the observations with regard to the height of Black Mountain, the question with regard to the relative accuracy of level and barometer will be set at rest, at least for such high altitudes.

The report of Lieut. Williamson does not state what means were taken to secure the greatest accuracy, though it is presumed that every precaution was adopted. The survey appears to have been conducted thus:—The party divided; one portion remained in camp and made hourly observations with the barometer; the other ran a line of levels along the route to be surveyed, and made hourly observations with the barometer also; the heights of those stations at which the levelling party made barometer observations, as determined by the level and barometer, were then referred to the station in camp. The observations made with the barometer in camp and along the route were noted at the same instant, and thus the party carried out the instructions of Biot on that subject.

SOME REMARKS ON THE CONTENTS OF THE ALBUM OF VILLARD DE HONNECOURT.*

By H. B. Garling.

If anything might be expected to prove interesting and instructive to architects of the Nineteenth Century, occupied constantly in the attempt to instil new vigour into their art, by investigating the principles by which it was regulated at a period when it was practised under healthier and happier influences, it must be some document which should throw light on the professional character, the method and objects of study, the feelings and the habits of thought of those artists who fixed those principles and decided their expression, but of whom individually we know nothing beyond that which is afforded by the reflection of their mind exhibited in their works. Such a document is the Album of Villard de Honnecourt, the contents of which I propose to sketch briefly this evening, and which, although they may not satisfy all the curiosity we feel, nor convey much instruction to those before whom information must be laid in its most obviously practical and tangible form, yet will be found replete with interest, and suggestive of abundant matter for speculation.

The history of the manuscript is told in a few words:—It was originally discovered in the library of St. Germain des Près, and subsequently transferred, on the confiscation of ecclesiastical property, to the National Library. It consists of thirty-three sheets of parchment, about three-fifths of the original manuscript, which consisted of fifty-two.

The manuscript was first noticed by Willemin in his 'Monuments Français inédits.' Later, in 1849, Mons. Jules Quicherat, Professor of Archæology, published a notice of the author, with a few of the sketches. It was however reserved for the industry and enthusiasm of M. Lassus to present it to us in its entirety in fac-simile, illustrated with all the skill of an accomplished artist, and all the learning of an experienced archæologist. Of the author, Villard de Honnecourt, we gather incidentally a few particulars from a careful analysis of the legends, and a comparison of the dates of historical events with those mentioned in the book. He appears to have been born at Honnecourt, on the Scheldt, near Cambray, and he writes in the Picard patois. There is great reason for believing that he was the architect of the choir of Cambray Cathedral, now unfortunately destroyed. He tells us that he travelled much; he visited Laon, Chartres, Lausanne, and Rheims, the latter place undoubtedly during the progress of the works at the cathedral; we get, therefore, an approximate date, somewhere between 1230 and 1250. He was then sent for into Hungary, where he stopped many days. Now we find that in 1242, Strigonia, then the capital of Hungary, was destroyed in an irruption of the Tartars, and that on their being driven back the next year, Bela, the King of Hungary, commenced rebuilding the city and the cathedral dedicated to the Virgin; and we may presume that Villard de Honnecourt, then a man of great reputation, was sent for to design and execute these works. It is alleged by the editor, M. Lassus, that there are various churches in that neighbourhood which exhibit evidences of French influence. All these dates and circumstances compared, give us some data for fixing the identity of the artist.

The contents of the book may be arranged under the following heads, viz.—1. Mechanical Contrivances. 2. Geometry and Practical Trigonometry. 3. Cutting of Stones and Masonry. 4. Carpentry. 5. Design in Architecture. 6. Design in Ornament. 7. Drawing of the Figure. 8. Furniture and Utensils. 9. A variety of Drawings, sketches from natural objects or from paintings either mural or on glass, for application to various decorative features in architecture. We therefore see that it embraces every department of an architect's studies. Many of the sketches have legends attached, describing them with more or less minuteness. On the page originally the first, is a legend forming a sort of introduction, and proving I think beyond all doubt, that the Album was not a mere memorandum-book for the author's own use, but that it was intended for the instruction of others, and that it contains a general sketch of the art practised in that day, as illustrated by the author's own experience. The legend reads as follows:—"Villars de Honnecourt salutes you, and prays all those who work in the various kinds of work contained in this book to pray for his soul, and to remember him; for in this book one may find great assistance in learning the principles of masonry and carpentry; you will also find in it the method of drawing the figure as geometry commands and enjoins."

Under the first head, Mechanical Contrivances, we have a saw-mill moved by water power, a machine for cutting piles under water, a screw-jack resembling that now in use, the method of forcing back into the perpendicular timber-buildings that have bulged, military engines, mechanical toys, and a curious scheme for perpetual motion, with several other matters.

Under the second head, Geometry and Trigonometry, a variety of problems more or less useful, some for setting out, or proving the truths of the setting out of work; for a variety of purposes connected with the practical application of geometrical lines and figures in architecture; for ascertaining the measurements, dimensions, and distances of inaccessible objects; for striking a variety of curves, and other things of minor importance.

Under the third head, Cutting of Stone, numerous problems and methods for setting out the lines of the more difficult and complicated parts of construction, the voussoirs of arches and vaulting in various positions, voussoirs of arches circular on plan, moulds for cutting the stones for spires, the best methods of bonding piers so as to conceal the joints, or to break joint, lines for constructing pendant arches, for corbelling from angular towers, and a variety of other matters of more or less interest.

Under the head of Carpentry, designs for three roofs and for a timber bridge. A portion of this division of the work has been lost.

In Architecture, we find internal and external elevations of one entire bay of the nave of Rheims Cathedral, and of the chapels of the choir, sections of the flying buttresses, and details of the mouldings and plans of the piers, with the bond marked; plans of the churches of Cambray and Vaucelles, now destroyed, and of the Tower of Laon, with an elevation and sketches of the rose windows at Chartres and at Lausanne; the latter from memory, and very incorrect. The sketches of Rheims appear to have been taken from the working drawings, for they show precisely the sort of variation likely to occur between the original design and the work when executed.

In Ornament, we have sketches of foliage, animals, grotesque and natural, and a variety of similar objects scattered through

* Paper read before the Royal Institute of British Architects.

Digitized by Google

the book. In Furniture, designs for stall work, for a maison d'orologe, as he calls it; for a lectern and a monumental cross, and one or two other matters.

Under the last head there are a variety of subjects, either for mural painting, for stained glass, or for sculpture; some are particularly beautiful, as that of Christ on plate 20, and again that on plate 31; there are also some very good sketches, of which the subject is not very intelligible, but which are well worth attention; a Descent from the Cross, the Twelve Apostles, figures and compositions emblematical of various sacred subjects, suitable as decoration in various ways in ecclesiastical buildings: the figures are generally very well draped. There are also sketches from nature, academic studies, with one or two evidently from classic subjects, as one of a sepulchral monument, and some apparently of bas-reliefs representing the Games of the Circus.

It may be alleged by some that but little information of practical use can be gleaned from the matter contained in this book; but I submit that this wholly depends on the faculty of gathering ideas in the individual himself—to the wise a hint suffices—to the artist, to the man of idea, the barest outline, the simplest fact, is frequently suggestive of the brightest creation,—to such it is addressed, and such will undoubtedly reap profit. For the man of dull perception, of mechanical routine, for the man who mistakes an incapacity for rising above practical matters for a special aptitude, for him who learns by rote only, and practices by precedent,—for such this book is certainly not intended; but to such men, we must remember, are we indebted for much of that which renders our art contemptible in the present day.

Having thus sketched briefly the contents of the album, allow me to say a few words on the character of the author, and of the artists generally of that interesting period, of whom we may assume that he was a fair type.

There is no pretension to mystery—no secrets of craft. We find him a man of restless activity of mind, of singular versatility of talent, and of powers of observation at once subtle and comprehensive; eager to gain information from every source, ready in applying it to every purpose. He appears to have resembled (taking the standard of his age) the ideal character sketched by Vitruvius—the man of universal accomplishment, the *facile princeps* in every art—trying his hand at everything, and proving himself master of all. Thoroughly versed in all the practical science of his day, we should suppose that this alone was his forte, from the attention he enjoins to its precepts, did we not find that it simply assists him to the more perfect mastery of higher accomplishments. In mechanics, he gives us now a mechanical toy and now a military engine, machines for cutting timber, hoisting, screwing up, and executing the rougher preliminary operations of building. In architecture, he studies only from the most beautiful subjects and the best models, and educates his powers of hand and eye to the highest vocation of the artist. He gives us sketches of natural objects to be applied to their most appropriate places in design, drawings of mouldings, and details, all of exceeding beauty. To geometry he pays the reverence so characteristic of his age, and would fain make us believe that his skill in free-hand drawing is simply a more refined application of its principles. As an artist, he adds the finest feeling in design, in some instances, to the most enviable skill in draughtsmanship; the conception just, appropriate, and spirituelle, expressed by the outline firm, vigorous, and free.

But applying these remarks to ourselves, and assuming him to be the type of the artists of that age, let us note particularly the wide and unrestricted field over which they spread their studies, how thoroughly eclectic they were in their habits of observation, how they swept off everything that came in their way, sacred and profane, that offered new ideas and new images; with what honesty they set themselves the task of meeting the requirements of their age, how candidly they admitted its conditions, how thoroughly they expressed its spirit; and this liberal, and catholic, and unprejudiced view brought its natural reward, in inexhaustible fertility of invention, in unerring propriety of application, and in matchless vigour and originality of expression. For we must remember, where genius, essentially the creative power in man, exists in the greatest degree, we shall find, if we analyse its operations, that it does not create new forms or new images, but simply creates new combinations of images and forms already existing; and that by natural consequence, its powers are disciplined, nourished, and perfected by abundant observation, and its stores increased only by the accumulation of matter, of raw material, so to say, which it renders back again refined, wrought up, transformed, and combined in endless variety, by those processes which genius alone can effect. Can we then by study that accumulates matter, by education that disciplines thought, hope to rival the glories of the great epochs of art? I mean of those periods when it had such truth and grandeur, when it aimed so high, and so nearly attained its mark, that it became the standard, the starting point for everything that followed. Most assuredly not; for the true causes of this excellence lay infinitely deeper than any we can touch by the most skilful training. If we examine the history of the time we shall find that all these great awakenings, so to call them, followed hard upon some mighty political convulsion, some movement of a character so deep that it stirred up from the very bottom that class of feelings and emotions which, when the tumult had subsided, find their natural expression in poetry, and in the most truly poetical phases of art. Convulsions so absorbing in their influence that they forced everything into one channel, so comprehensive that they left no space for rival influences, so powerful that they communicated impulses of which the duration may be reckoned by centuries, and which, like undulations from a common centre, became feebler as they widened in circuit, till crossed by counter influences they exhibited only a surface of troubled water, as in our own day, heaving indeed tumultuously, but moving in no definite direction, attesting only the mighty force of the first impulse, and the elastic and impressible element through which it was propagated. Such convulsions were the Persian invasion in classic, and the Crusades in later times; for though the direction of these two great events was different, the feelings and emotions they roused were identically the same, and their effects precisely parallel. The results in each instance were precisely the same. In the Greek, of more ethereal temperament, they were more rapid, more brilliant, and more dazzling. In the Goth, of sterner mould, they were more solid and more enduring. The one gained at a bound the height, which the other reached by slower steps but sure; the influence of the one expired, for though lofty it was essentially human; the other survives, through the Divine element with which it was interwoven. I say, then, a combination of influences only, such as occur but twice or thrice in the history of the world, at particular stages of advancement in knowledge and civilization, can alone produce what we desire so earnestly to see in this our own day. Shall we, then, do nothing? Certainly not. If we cannot do all we could wish, we can easily achieve some improvement, and I would make a few suggestions in furtherance of this desirable object.

First,—That enlarged study will remove narrow prejudices. Secondly,—That it is by thorough digestion, and not by the accumulation of matter, that we learn to invent. Thirdly,—That to copy great works is not to imitate great masters. Fourthly,—That it is only in the Nineteenth Century that fine art is considered one thing, and the vernacular, so perhaps truly named, another; in the Thirteenth, the vernacular expressed the popular want, the necessity of the case, the conditions of design; while fine art showed how the artist could refine what was coarse and vulgar, ennoble what was mean, and spiritualise what was gross and material,—his proper and highest vocation. Lastly,—That the benefit of enlarging our views beyond the limits of one phase of art, of adopting that eclectic method in study which enables us to appropriate some meritorious principle of another style, without confounding its distinctive character, which is chiefly expressed in detail, is singularly evidenced in the case of that particular school of artists who most strongly insist on the opposite principles; for we must admit that, after twenty years of unremitting investigation, after thousands of experiments in the revival of Mediæval art, the only symptom of real advance in meeting actual requirements by some new combination or idea, is the abandonment of the mullion, the adoption of the horizontal lintel, and the introduction of the monumental column; all so essentially classic in character that they were but a few years back instanced as a reproach to that style, as evidence of false principle and inappropriate expression. They do exist we know well in Mediæval art, but this simply adds weight to the point I insist on, viz., that it is necessary to enlarge our field of study, and to accumulate facts, before we decide on our principles, and that this point, so essential in practical science, is equally applicable to all the arts of design.

Digitized by Google

In the discussion which followed, Mr. BURGES said he had carefully compared M. Lassus' work with the manuscript. He thought the original drawings had been made with something like an ordinary black-lead pencil, probably a lead point, and that the lines were afterwards traced over with a crow-quill. The ink used was generally of a brown colour, in some parts nearly black, but in others the lines were of a light yellow. De Honnecourt did not state that he built Cambray Cathedral. It was only known that he visited Hungary; but he was probably a man engaged upon one work at a time, who therefore had not the opportunity of leaving the impress of his style all over the country. It would be interesting to know with certainty whether he had made his copies from the actual working drawings. It was evident that he copied what he wanted to reproduce, with such modifications as occurred to him. His drawing of the figure was peculiar, and appeared to be a method of free-hand copying, by dividing the subject into geometrical outlines, by which means he could dispense with a knowledge of anatomy; however, with all their faults, his figures were better drawn than they would be by the majority of living architects. Under the present system, drawing of the figure seemed to be quite neglected. Instead of being educated as an artist, the student was placed in an office, and told to pick up what he could; the result was, that instead of one good work on which he might display all the resources of his genius, he was often forced to produce some fifteen or sixteen small and insignificant churches.

Mr. PAPWORTH said that De Honnecourt's book was far more interesting than the preface or introduction to it by M. Lassus, the editor, who claimed for France the merit of almost all the great architectural works of the period, including even Burgos Cathedral. Indeed, all that was really good in the preface was taken from Pugin's 'True Principles of Pointed Architecture.' The book and the preface were, in fact, directly opposed to each other, for M. Lassus urged that no new style of architecture could be arrived at; that there must be either an entire retrogression or the adoption of a *rifacciamento* of former styles. Mr. Papworth showed that, in opposition to the exclusive devotion given by each section of the profession to its favourite period of Pointed Art, De Honnecourt's mode of study was literally eclectic, as was proved by his imitations of Classical and Byzantine art, and by his studies from the life. The principal reflection which had occurred to him after looking at the contents of De Honnecourt's Album, was that architects in the present age attempted to know a great deal too much of everything beyond their own real business. It was too much to expect that architects, besides making their own working drawings, should be good painters, sculptors, and, in addition, masters of all handicrafts, whether incidental or not to the execution of a building.

Mr. M. DIGBY WYATT observed that the work under consideration was one of the highest interest historically, if not æsthetically, for it established three facts, of which doubts had been generally entertained until the discovery of De Honnecourt's treatise, viz., that in certain instances in the north, as had constantly been the case in Italy, the architect and the sculptor, or the designer of the sculpture, were combined in the same person, —that the architects and sculptors of the middle ages studied from animate and inanimate nature freely,—and that the whole tendency of the Mediæval style during its purest period was to extreme simplicity of design. The parts were repeated in regular succession and reduplication, without eccentricities, to create the picturesque, as was shown by the sketches before the meeting.

Mr. G. GILBERT SCOTT observed, that it was interesting to see something, however little, of the interior of the studio of an artist of any great period. It would, for instance, be of the greatest use if we could learn how and in what spirit the Greek architects expressed their ideas in private. Mr. Garling's paper was one which ought to excite interest, if only from its important bearing upon the history of their art; and even if M. Lassus' suggestions were somewhat conjectural, it should be remembered that mere conjectures had their value. The idea that De Honnecourt introduced French Gothic architecture into Hungary, was an interesting subject for investigation, although the grounds on which M. Lassus argued the point were rather slender. But passing by these conjectures of the editor respecting the origin of De Honnecourt's mission to Hungary, upon which the artist himself had not thrown any light, he would mention, as one of the most interesting points in De Honnecourt's book, the manner in which he appeared to have seized upon everything he saw at all likely to aid him in his art, and the marvellous facility with which he sketched it Speaking generally, he (Mr. Scott) did not believe that architects of the present day could draw the figure so well as De Honnecourt. Mediæval drawing might be considered quaint, and that of our own day excessively pretty; but, quite apart from the sketches of De Honnecourt, he would suggest what had long pressed itself upon him as a very important practical consideration, that in all great periods in architecture the amount of skill in drawing, whether more or less, was directed to the great object of rendering the work itself artistic, particularly in its decorative features, and very little of it to making pleasing pictures of the building, either before or after its execution; whereas at the present day the reverse was the case; the artistic attainments of architects, whether Classic or Gothic, being, with some exceptions, mainly devoted to making pictures of buildings, and only in a secondary degree to the perfecting of the artistic portions of the actual work. He could mention several gentlemen of both denominations who could draw in a most magnificent manner; but he had long felt the want of schools for artistic training, in which students should be systematically instructed in those higher branches of art which do not bear upon mere picture-making, but upon the actual art to be expended on the works themselves.

Mr. MARRABLE differed from the concluding remarks of Mr. Scott, as to the incapacity of modern architects to make correct drawings from which the men could work. According to his experience, every architect worthy of the name was capable, and many of them were indeed artists who could represent their designs in an artistic and pleasing way, without confining themselves to such rough and rude drawings as those of De Honnecourt. He could not but regret that so much time and patience had been devoted to preparing a paper which was more interesting in an archæological than in an architectural and practical point of view.

Mr. M. DIGBY WYATT observed that the history of art was the best lesson to set before the student, old or young, and without going so far as Mr. Scott, in depreciating the practical artistic works of the majority of the architects of the present day, as compared with those of the older architects, he believed that a very great and valuable lesson was to be learnt from any traces of their mode of practice and study which could be rescued from the past. On these grounds he certainly believed that Mr. Garling's paper had been judiciously brought before the members.

Mr. PENROSE said that the Institute had often received papers that were too strictly archæological, but the present, though treating of what was old, was architectural. It touched moreover closely upon realities, and was essentially valuable as giving an insight into an ancient studio. It was in fact a paper of practical importance; and thanks were fairly due to Mr. Garling for the pains he had taken in bringing it forward.

REPTON SCHOOL CHAPEL.

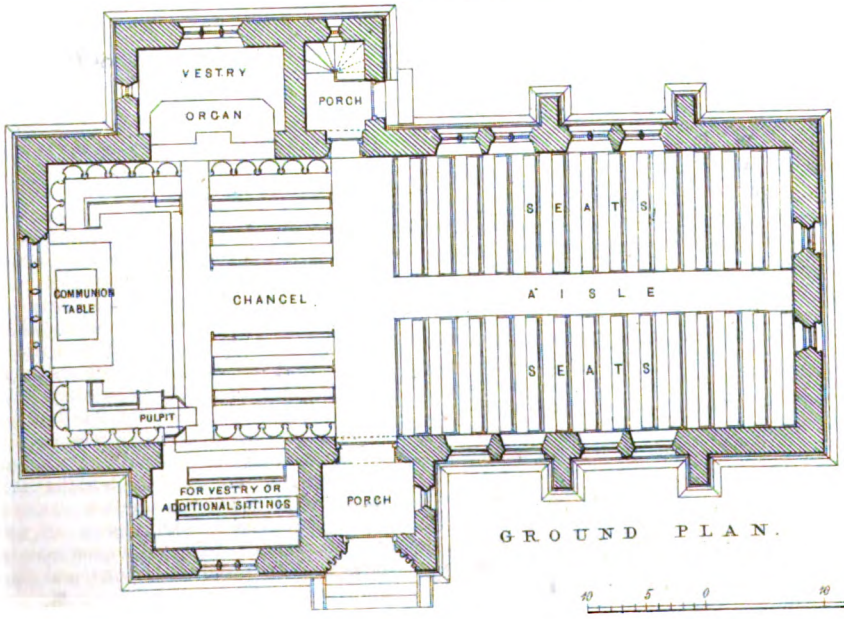
(With an Engraving.)

AT the tercentenary of the school, celebrated on the 11th and 12th of August, 1857, liberal subscriptions were promised for a memorial fund; the majority of the contributors giving preference to a chapel, as being at once the most appropriate and the most likely to contribute to the future interest of the school, and the maintenance of its present high position. A committee was formed, and a correspondence entered into with many old Reptonians and well-wishers of the school, in order to carry out this object. The committee being unable to obtain a site in the Priory ground, secured a most eligible piece of land on the brow of the hill leading up from the railway station. The foundation stone of the new chapel, of which we present a perspective view and ground plan showing the internal arrangements, designed by Mr. J. H. Stevens, of Derby, was laid by the Rt. Hon. Earl Howe, on August 26th last, and is now roofed over. Below the cornice on the outside of the building are panels for inscriptions; one describing the object of the building is as follows:—DEO . SERVATORI . HANC . ÆDEM . SCHOLÆ . REPANDVNENSIS . PER . ANNOS . CCC . INCOLVMIS . PRÆSIDES . ALVMNI . AMICI . POSVERVNT . A.D. MDCCCLVIII. The estimated cost is about 3000*l*. The walls internally are faced with stone, and the fittings are of oak.

Digitized by Google



PROPOSED MEMORIAL CHAPEL, REPTON SCHOOL.
J.H. STEVENS, ARCHT.



GROUND PLAN.

J.R.Jobbins

Digitized by Google

Digitized by Google

THE MAIN DRAINAGE OF THE METROPOLIS

(*Concluded from p.* 392.)

The result of the objections put forth by the Metropolitan Board of Works, was that the Referees addressed a further communication to the First Commissioner, bearing date Nov. 12th, 1857, in which, while defending the major part of their recommendations, they modified their scheme in the following particulars:

The main outfall sewers which were to have been open for the greater part of their length, were now proposed to be covered except near their lower ends.

For the purpose of avoiding the "depressions" alluded to under the term syphons, the depth of the sewers was to be increased so as to enable the several streams to be passed without any depression of the bottoms.

Instead of the respective widths of 39 and 37 feet assigned to the channels on the first plan, they were now to be 25 feet and 22 feet wide at the head respectively, gradually increasing to 60 feet and 57 feet in width at the outfalls; the depths being increased by 9 ft. 6 in. and 10 feet respectively at their upper ends, and at their lower ends by 3 feet and 3 ft. 6 in.; they were also to be brought to an uniform fall of 6 inches to a mile. These sewers were now proposed to be made tidal throughout their whole length, the tide entering from their lower ends.

In defending their selection of the points of outfall the Referees urged, in reply to the objection of the Metropolitan Board, that the gain by going fifteen miles lower down would be partially lost in consequence of the discharge taking place at or near low water; that the discharge of the sewage in dry weather would take place during the greater part of the ebb tide, and that the sewage would not be returned up the river with the rising tide to the extent apprehended, because the currents at the points selected are very strong during and until the last of the ebb tide, while a considerable period of slack water occurs at the commencement of the flood tide; and from the set of the currents, a very limited portion of the sewage would have a tendency to move up the river.

The Referees describe the outfall channels of their second plan as being designed upon the principle of tidal creeks, the object in so designing them being to fix a level little above that of high water in London, as the point to which the sewage should gravitate in the metropolis.

At the upper end of the channels gates would be constructed to admit water from the Thames, whenever the level of the water in the river was higher than the level of the water in the channel.

The channels were proposed to be worked in either of the two following ways, viz.:

"1. Gates would be placed at a point 20 miles from the head, so constructed as to allow of the egress of the sewage whenever the level of the water in the channel was higher than that of the river at that end, but to exclude the ingress of the tide beyond that point.

"According to this arrangement, the gates would close soon after low water, and the water from a reservoir at the upper end, of about 20 acres in extent and 5 feet deep, filled at the previous tide, would be allowed to flow into the channel for about three hours, at a rate including the sewage flowing in of from 500 to 600 cubic feet per second, by which means a velocity of about 2·75 feet per second would be obtained at the upper end. When the tide had risen at the upper end to a level higher than the water in the channel it would flow in; and by the time of high-water it would occasion a velocity of upwards of 3 feet per second at the upper end. This water would accumulate at the lower end sufficiently to stand above the level of the river at that end at about two hours after high-water, when the sewage would commence to discharge, and continue doing so during the remainder of the ebb tide.

"By the second method of working, the channel would be left open at the lower end to the ebb and flow of the tide."

In this case the water from the reservoir at the upper end was proposed to be admitted at about one hour after the period of low water, occasioning the same velocity at the upper end as in the former case; and as the tide would not flow up the channels so rapidly as up the river, it was calculated that the water entering into the channels at the upper end, and flowing down, would meet the water from the lower end at about the fifth or seventh mile. "The velocity at the head would then be upwards of 3 feet per second, and the flow for the first five or seven miles would always be maintained in the direction of the outfall."

The reservoir on the north side was now proposed to be situated in Channel Sea Island, and that on the south side in Greenwich Marshes.

The outfall channels modified in the manner explained were calculated to add the sum of 550,000*l.* to the amount originally estimated.

The main point of difference as affecting the dimensions of the sewers, is the large amount of rainfall within the metropolitan district which the Referees considered it essential to provide for.

It was proposed in the plan of the Metropolitan Board of Works to remove one-fourth of an inch from the urban districts, and from the suburban districts a quantity varying in the different localities from one-eighth to one-sixteenth and one-thirty-second of an inch, in a period of twenty-four hours—these proportions being calculated to prevent the sewage from flowing into the river at all times, except during twenty-eight days in the year on the average. It appears that this average was derived from observations made in 1855.

The Referees objected that the average rainfall in London is one-fourth greater than the rainfall of the year selected by the Board of Works; and that from the quantity of rain which fell in 1851, the number of days on which sewage would have overflowed into the Thames would probably have been three or four times the number of days given by the Board as an average; and further, that the question of the amount of rainfall to be removed without polluting the river cannot be governed by the amount which falls spread over a period of twenty-four hours, but by the amount which falls during the period of eight hours when the sewage is flowing at its maximum.

The real reasons, however, which appear to have influenced the Referees in determining the amount of provision to be made in the sewers for the rainfall, seem to have had reference to the attainment of the amount of dilution requisite to give to the sewage the volume necessary to the maintenance of the theoretical velocity, upon which the proportions and fall of their main outlet channels were designed.

In regard to the objection that the removal of the rainfall from the Thames to the extent recommended would take away a powerful agent in scouring the river, the Referees observed: That the drainage area of the basin of the Thames above Woolwich is about 4640 square miles in extent, from which they propose to remove a portion of the rainfall taken from an area of about 350 square miles in the tidal portion of the river, amounting to nearly 8,000,000 cubic feet per hour during the period of the eight hours of maximum flow, and about 11,500,000 cubic feet during the average flow. If the latter quantity could be placed at once into the Thames at high water, it would occupy a layer in the tidal part above Woolwich about half an inch in depth, and on this assumption the effect of its removal would be inappreciable.

In answer to an application of the Metropolitan Board of Works for further particulars, the Referees suggested a third plan by which the reservoir on the south side was proposed to be placed near Deptford creek on the north side of the Greenwich railway station; and the course and sections of the outfall channels were modified in various essential particulars.

The north reservoir on this plan is described as to be of 15 acres area, and the south reservoir 10 acres; and both were to be 12 feet in depth below Trinity high-water mark.

The north reservoir was proposed to be capable of running into the channel about 500 cubic feet per second at spring-tides, and about 320 cubic feet per second at ordinary neap-tides, for a period of four hours, commencing at the time of low water at the outfall.

The south side reservoir would have run about 350 cubic feet per second at spring-tides, and about 220 cubic feet per second at neap-tides for four hours.

These quantities, together with the calculated mean dry-weather discharge of sewage (180 cubic feet per second on the north, and 160 on the south side) give the following quantities for four hours each tide; viz.:

	Spring Tides. cubic ft. per sec.	Neap Tides. cubic ft. per sec.
On the north side	680	500
On the south side	510	380

By these arrangements it was calculated that scouring velo

Digitized by Google

cities would be obtained at the heads of the channels, and for 6 or 8 miles towards the outfalls, of 2 ft. to 3 ft. 6 in. per second, according to the state of the tide and the quantities of sewage.

About the time that the reservoirs would become exhausted, viz., four hours after flood-tide at the outfalls, the tide would have attained the level of the sewage at the head of the channels, and would pour in during the remainder of the time up to high water, causing a scour through the upper 12 miles of the channels, varying from 4½ feet per second at the head, to 2½ feet per second at 12 miles. At high water the reservoirs would be shut up, and the water reserved for the next scour at low water.

The dimensions suggested for the outfall channels in the first plan having been calculated in error for too large a storm-flow, the Referees in their third plan altered the dimensions accordingly; a modification which they calculated would reduce the cost by about 350,000*l*.

Having in their observations, dated 12th November, 1857, described a double method of working the outfall channels, the Referees, in reply to the specific inquiry of the Metropolitan Board of Works, replied, that gates should be provided at the lower end, and that in their opinion it would be found advisable generally to keep the gates closed on the flood-tide, but that it might be found occasionally desirable to admit the tide.

The Metropolitan Board of Works entertaining strong objections to some of the recommendations of the Government Referees, and anticipating insurmountable difficulties in the execution of the schemes proposed by them, resolved to refer "The Reports of the Board on the Main Intercepting Drainage of the Metropolis," and also "The Reports of Messrs. Galton, Simpson, and Blackwell upon the same subject," to the engineer of the Board, together with two other civil engineers, with instructions to report to the Board as to the best means of carying out the main drainage of the metropolis.

Messrs. George Parker Bidder and Thomas Hawksley were associated with Mr. Bazalgette for the above purpose.

On the 6th April, 1858, these gentlemen presented their report upon the Main Drainage of the Metropolis.

This report gives a complete comparison and analysis of the various plans, reports, observations, and experiments of the Government Referees, with reference to the various parts thereof, and as bearing upon the plan submitted to the First Commissioner of the Metropolitan Board of Works.

The Metropolitan Board of Works having already determined upon the adoption of a system of main intercepting drainage, and it having been decided upon generally approved principles, that that drainage should, as far as practicable, be carried out by lines of arterial sewers, running parallel with the river Thames on both sides of the river, the Referees of the Board did not consider themselves called upon to investigate the merits of the various proposals that have from time to time been presented to the public. The points which remained to be definitely settled, and on which they considered it their duty to report, are, however, of the highest importance:—The area to be drained; the amount of sewage and rainfall to be provided for; the dimensions of the sewers; the points of outfall, and the mode of reaching them; and the possibility of purifying and improving the river, received the most careful investigation from the Referees of the Board themselves, and from other gentlemen whose aid they sought on collateral matters not falling strictly within the sphere of their own professional avocations.

As the result of their examination of the report of the Government Referees upon the outfall sewers, Messrs. Bidder, Hawksley, and Bazalgette direct attention to many errors and discrepancies, which, in their opinion, tend to weaken the recommendations of the Government Referees in reference to the dimensions and construction of the main sewers and the locality of the points of outfall.

At the threshold of the inquiry they consider that the experiments of Mr. Blackwell, which afforded the data upon which the Government Referees determined the velocity requisite for the main outfall channels, do not apply to the case of accreted deposits in sewers and rivers, which are formed under conditions totally different to those which had place in the experiments in question. The substances to be moved were placed on a wooden floor, were for the most part isolated, and were not cemented together by the matter of the deposit in the manner of the substances which are usually to be found in the beds of even quickly-moving streams. The result of the experiments was to the effect that heavy substances of various sizes could be moved on a boarded floor by a stream having a velocity of 2½ feet per second. Any one, however, may observe on the Thames bank fine deposited mud resisting the action of currents of 4 feet and even 5 feet per second, and in the River Mersey sandbanks are formed, although the tidal velocity is 8 or 9 feet per second.

In the plan first proposed by the Government Referees, the two great outfall sewers were to have been partially uncovered, and partially tidal.

The sewage in these uncovered sewers was to be diluted by six or seven times its own bulk of water, to be derived occasionally from storm-waters, and at all other times from reservoirs to be filled by the Thames.

These reservoirs were proposed to be placed—1. On the north side at Plaistow;—2. On the south side in the valley of the Ravensbourne.

By the Government Referees' second plan,—1. The outfall sewers were materially altered in size and shape;—2. They were now to be covered, excepting at the lower extremities;—3. Their levels and inclinations were varied;—4. They were to be "tidal" throughout. The inverts of the sewers were also to be lowered nearly 10 feet at the upper end, and 3 feet at the lower end.

The reservoirs were now to be placed—1. On the north side of Channel Sea Island;—2. On the south side in East Greenwich Marshes.

By the third plan the following changes were proposed—1. The sewers were to be reduced in size and again altered in shape;—2. They were again to be "tide-locked;"—3. The inverts were to be still further lowered. The reservoirs were reduced in size, and that on the south side removed from East Greenwich Marshes to Deptford Creek.

In regard to these various plans and modifications of plans, Messrs. Bidder, Hawksley, and Bazalgette observe:

"The information afforded with respect to all these plans is throughout imperfect, and in many respects contradictory or discrepant. The general design is to convey the sewage by long lines of outfall channels, terminating at points very remote from the metropolis; to provide for the removal of the sewage of a prospective population, estimated at what it may be forty years hence, at the rate of 7 cubic feet of sewage per head per diem, and for a rainfall equivalent to many times that amount of sewage. But as to the particulars of this project the greatest uncertainty exists. The long lines of outfall sewers are at one time to be uncovered, at another to be covered. The levels are different under each plan. The inclinations are variable under one plan and uniform under another. One set of plans provides for a certain specified flow, but another set for a "revised flow," on the allegation that the earlier plans were adapted for too large a flow. In the several plans the sewers are varied in form and area, and the position and magnitude of the reservoirs are altered. Having reduced the dimensions of the sewers, their direction is also greatly varied, although the first proposed was stated to have been made upon the most careful surveys. Last of all these plans vary in the essential particular as to whether the tide is, or is not, to be admitted into the outfall sewers. Upon this point even the first plan is indistinct. A difficulty of a similar kind is also experienced as to how the water of the Thames is to gain admission into the outfall channels, seeing that even at ordinary high water the level of the surface in the sewer is to be above the level of the surface in the river. By pumping only could the proposed object be attained; and yet no provision for the cost of the machinery and buildings, and for the working expenses, has been made in the estimates."

The difficulties which the remote outfalls involve in the valley of the Thames are sufficiently evident on a consideration of the plans proposed by the Government Referees. The construction of outfall works for the drainage of a *low* district by *gravitation* to a *remote* point, where the only attainable fall is a portion of the difference of level between high and low water marks, is only possible at an enormous sacrifice of time and money. The small declivity of the channel, incident to great length, necessitates large dimensions, and these again involve a proportionately large outlay.

In order to carry out the principle of drainage by gravitation aided by dilution, it became necessary to make large portions of the channels more than *eight* times what would have been the required capacity upon any reasonable calculation for the drainage of an enlarged metropolitan area, extending to Hanwell and Richmond, as they estimated such an area would be populated forty years hence.

Digitized by Google

The stream of water adequate to give to these sewers the hydraulic depth requisite to insure a sufficient velocity to keep them in a working state is only provided by nature on a very few days in the year. The Referees were consequently forced to suggest reservoirs at the head of each of the outfall sewers, in order to supply the deficiencies in the rainfall. These reservoirs involve not only additional difficulties, but even if practicable would entail such enhanced first cost and subsequent annual outlay, as to render the project extremely objectionable.

The quantity of water required for the dilution of the sewage as calculated by the Referees (see table, p. 275, vol. xxi.), amounts to no less than 183,059,370 cubic feet per diem. The difficulties of obtaining this supply in the localities originally proposed for the reservoirs would be considerable, but the difficulty of locality would by no means have been the greatest difficulty affecting the plan for these reservoirs. The level adopted by the Government Referees for the top water line of their outfall sewers, being a little above that of the highest tides, viz., 5 feet above Trinity high-water mark, it is obvious that the reservoirs could not be supplied from the Thames with water at a level high enough to flow into and fill the outfall channels. Except then when the rainfall proved sufficient for the purpose, the whole quantity of water required for the dilution of the sewage would have to be pumped up.

The pumping power required was calculated by Messrs. Bidder, Hawksley, and Bazalgette, as follows:—The level of the water in the outfall sewers being 5 ft. 6 in. above Trinity, which is 9 feet above the mean height of the water in the reservoirs, the water must be lifted a medium height of 14 ft. 6 in., and a maximum height of 23 ft. 6 in. Machinery, therefore, must be provided for raising 61,000,000 cubic feet of water in eight hours to a height of 23½ feet. This duty would require engines of the aggregate power of 5600 horses. As, however, half the daily flow of the sewage would pass off in eight hours, the quantity flowing into the sewers within that period would be 50 per cent. in excess of the mean flow. In order therefore to dilute the sewage to the extent proposed by the Referees, the dimensions of the reservoirs, sewers, and engines must be proportioned to one-half more than five times the ordinary sewage, or to 210,000,000 cubic feet per day instead of 183,000,000 cubic feet as stated by the Referees.

Messrs. Bidder, Hawksley, and Bazalgette give it as their opinion that to construct reservoirs of the necessary extent would, if practicable, involve an immense expense, and that the annual interest upon outlay, the cost of cleansing out the deposit left by every succeeding tide, and the expense of maintaining and working the machinery could not be expected to entail a burden upon the inhabitants of less than 100,000*l.* per annum, equal to a rate of 2*d.* in the pound on all the assessable property within the metropolis.

In the second and third plans projected by the Referees, the inverts of the main outfall channels being lowered, the reservoirs were to be filled direct from the river at high water; and as we have seen, would discharge into the sewers for a period of four hours, commencing at the time of low water at the outfall, and after the reservoirs became exhausted, the tide would pour in direct from the river during the remainder of the time up to high water.

Upon this arrangement Messrs. Bidder, Hawksley, and Bazalgette remark,—that reservoirs of the extent proposed could not receive the quantity of water required for the sewer;—that the outfall channels would be tide-locked at their lower ends;—that a large deposit of mud would follow, and that the velocity of the current at the lower end would be insufficient for its removal.

A general examination of the Referees' estimates showed considerable deficiencies in the quantities, and the absence of adequate provision for many works necessarily involved in the execution of the plan. The amount set down for land compensations appeared to the engineers consulted by the Metropolitan Board too small, and the result of a detailed valuation by a professional valuer showed a deficiency of 440,000*l.* under this head alone.

Having re-estimated the works proposed by the Referees on their different plans, Messrs. Bidder, Hawksley, and Bazalgette put down the approximate cost of

Plan No. 1, at	£11,000,000
Plan No. 2, at	9,000,000
Plan No. 3, at	7,000,000

A material element of excess in the scheme of the Government Referees is the large provision made for the combined sewage and rainfall.

As to the sewage alone, there is in fact little discrepancy between the estimate of Mr. Bazalgette and that of the Referees, so far as regards the maximum amount to be removed, if the enlarged area suggested by the Referees be excluded from consideration. The assumptions however, upon which the respective results are attained, appear to be very different. The Referees assume the flow of sewage at 7 cubic feet per person per diem, while Mr. Bazalgette adopts in his calculations 5 cubic feet as the standard. The Referees assume that one-half of the whole diurnal flow will pass off in eight hours of maximum discharge; Mr. Bazalgette on the contrary estimates that one-half will flow away in six hours. The Referees provide for the wants of a population thirty or forty years hence of 3,578,089 persons, while according to Mr. Bazalgette's views, the total prospective population is 3,448,500. But the general result of the various hypotheses on the determination of the maximum flow is as follows:

	cubic ft. per min.
Referees' maximum flow	26,100
Mr. Bazalgette's ditto	23,694

the difference being only about 9 per cent., while the increase in the total diurnal discharge of sewage consequent on the extended area provided for by the Referees amounts to little more than 7 per cent.

But while there is this sensible accordance with respect to the maximum flow of the sewage, a great difference exists with regard to the amount of rain to be carried off. The provision for rainfall made by Mr. Bazalgette amounted to a diurnal fall of ·25 inch for the northern districts of the metropolis, and from ·125 to ·25 inch from the peopled districts south of the Thames, giving a result of about 34,000,000 cubic feet per diem.

The Referees proposed to carry off as much as ·867 inch of rain in 24 hours from that portion of the metropolitan area (about 50 square miles) situated on the north side of the river; and a daily rainfall of ·387 inch from the remaining area of 68 miles on the south side, producing together 160,500,000 cubic feet per diem. In addition, provision is made for carrying off from the district termed prospective by Mr. Bazalgette about 6,000,000 cubic feet, and from the enlarged area projected by the Referees, in round numbers some 16,500,000 cubic feet, making a total rainfall of 183,000,000 cubic feet per diem.

The sewers proposed for discharging this large rainfall, together with the daily sewage of the districts included by the Government Referees, would suffice to carry off double the dry-weather yield of the Thames, and are adequate to the conveyance of the sewage at the maximum rate from more than the whole population of England.

Messrs. Bidder, Hawksley, and Bazalgette think it important to draw attention to the distinction between the rain to be carried off, and the actual fall of rain on the drainage area; the former being only the residual quantity which finds its way into the sewers after the gross quantity has sustained a large but variable diminution by domestic use, absorption, and by evaporation.

The Referees urge with great correctness that the quantity of rain-water to be estimated for is not to be reckoned from the hourly proportion of the diurnal fall, but from the quantity which may fall during the period of the maximum flow of the sewage, and they give it as their opinion that a less proportion than five times the maximum flow of the sewage would not prevent the frequent discharge of storm-waters into the Thames, and that the storm-waters would at these times be so highly charged with sewage matter as materially to interfere with the purity of the river.

Messrs. Bidder, Hawksley, and Bazalgette take a different view of the case. Estimating upon the Referees' own data, that the total amount of sewage which would flow off an urban district is equivalent to a depth of 52½ inches per annum over the whole surface, and assuming the mean annual rainfall to be 25½ inches, of which as much as 17½ inches would find its way into the sewers, it follows, that to relieve the Thames of all sewage impurity, the whole $52\frac{1}{2} + 17\frac{1}{2} = 70$ inches must be annually intercepted. But to effect this, the capability of discharge must be adequate to effect the withdrawal of an extreme storm-flow, that is to say, a flow produced by a fall of 2 or 3 inches of rain in twenty-four hours, or it may be in three or

Digitized by Google

four hours. Hence to insure the removal of all the rainfall, though in the aggregate amounting to only one-third of the combined flow, would require sewers of a discharging capability at least twenty times greater than that needed for the ordinary sewage of the prospective population of the metropolis.

As sewers even of the dimensions of those projected by the Referees would be incapable of carrying off the whole of the rainfall during heavy storms, it becomes a question for consideration whether the mere diminution of the number of days in the year on which the storm-waters would overflow into the Thames, would not be too dearly purchased at the expense of the enormous works suggested; especially if continued experience should confirm the opinion held by many practical and scientific men as to the distinctive decomposition of sewage matter, without the aid of the putrefactive process, which speedily succeeds upon its admission into a large quantity of fresh and flowing water.

In comparing the plans for the internal drainage of the metropolis, the engineers consulted by the Metropolitan Board of Works observe, with reference to low and high level sewers,—

"If the metropolis were to be left dependent for its drainage on low-level sewers alone, it is manifest that such sewers must be constructed at a depth adapted to the efficient relief of the basements of the houses of the lowest districts. This depth would be for the most part below the level of low water, and consequently any such tunnel sewers would be incapable of discharging themselves by gravitation. In other words, the whole of the sewage of the metropolis, no matter from what elevation it might descend, must eventually be raised by mechanical power, to effect its discharge into the river. The sewers must also be capacious enough, and the engines large enough, to deal with the whole volume of rainfall and sewage intended to be conveyed to a distant outfall; and even this provision would not prevent the reaction of a flood proceeding from a high level."

It would be more economical, as well as more convenient to the public, that high-level intercepting sewers should be constructed for the purpose of receiving the waters of the more elevated districts, and conveying them by gravitation to points of outfall, at which they can be discharged, either without mechanical assistance, or with the smallest possible amount of such extraneous aid. The Referees were of the same opinion, and accordingly proposed works based on this principle, but gave a much larger application to it than was designed by the engineer of the metropolitan board.

The route of the high-level sewer on the northern side has received the approbation of all parties.

Mr. Bazalgette by his middle and low level sewer divides the populous district intervening between the high-level sewer and the north bank of the Thames into two distinct areas,—the higher to be drained by gravitation, and the lower by the aid of mechanical power. The Referees upon their system proposed to dispense with both of these sewers, and to substitute two other sewers,—the one to drain eastward to Abbey-mills, and then to discharge by gravitation into the northern outfall sewer,—and the other to drain westward to Battersea, and crossing the river to discharge by steam power into the southern high-level sewer. Independent of other objections advanced against the latter scheme, it is inferior to that of Mr. Bazalgette in the point that by adopting a more elevated contour he is enabled to discharge the whole of the water from his gravitating area into the river, even at high tide,—an advantage which the scheme of the Referees does not possess.

Mr. Bazalgette has proposed two schemes for the northern low-level sewer,—one to include the western portion of the metropolitan area,—the other to exclude that area. The whole question of the drainage of the very low lands between Chelsea and Hammersmith is one of considerable difficulty. The water must either be pumped, or be deodorised, or be suffered to flow into the river as at present. The engineers consulted by the Metropolitan Board having rejected—as would appear, without sufficient reason—the proposition of the Referees to carry the sewage of this district across the Thames to their pumping station opposite Battersea, come to the conclusion that no mischief will arise to prevent the Counters-creek, the Eel-brook, and other minor sewers of the western district, to continue to discharge for the present into the river below low-water mark.

On the southern side there is comparatively little difference between the plans of the Referees and the plans of Mr. Bazalgette. They both comprise a high-level and a low-level sewer, and both propose to concentrate the sewage at Deptford. The Referees' plan, however, includes a lift at Battersea for the Putney and Wandsworth waters. The engineers of the board, however, are unable, for reasons stated in their report, to see any advantages in the extension of the sewers westward along the southern bank of the river, and urgently recommend the adoption of Mr. Bazalgette's plan.

The total maximum flow and rainfall provided for by the Board of Works' plan, has already been stated at 47,913 cubic feet per minute, during six hours' discharge. On account, however, of some additions made to the area, of a higher estimate of the progressive increase of population in certain districts, and of a larger allowance for rainfall, Messrs. Bidder, Hawksley, and Bazalgette calculate on a total delivering power of 79,900,000 cubic feet per diem.

On the subject of the points of outfall, the engineers of the board express a clear and decided opinion that the remote outfalls proposed by the Referees are unnecessary for effecting the objects of the 135th section of the Metropolis Local Management Act. They unhesitatingly select, as points of outfall, Barking Creek on the north side, and Crossness Point on the south side, as fulfilling all the favourable conditions that are attainable on either side of the river. Both are situated in dreary marshes, where neither the works nor the sewage can give reasonable cause of offence. The mean sectional area of the river at those places is four times as great as at London Bridge, and the average volume of tidal water about *four hundred times* as much as the volume of sewage to be admitted into it; and the river is fresh, or nearly so, at low water, and only moderately mixed with salts of marine origin at high water. As compared with the outfalls proposed in plan B*, the points indicated, they consider, will answer better in a sanitary point of view; and the diminution in the length of the outfall channels they calculate will save a sum of not less than 350,000*l*.

The sewage is proposed to be discharged into the river during the first two-and-a-half hours of ebb-tide, the outlet being by submerged pipes terminating below low-water mark.

Reservoirs are proposed to be constructed at the terminus of each of the outfall channels into which the sewage is to be received. The reservoirs will be arched and turfed over, so as neither to permit the escape of effluvia nor to present any unsightly appearance.

It is intended to construct the reservoirs so as to enable the precipitation of the sewage matter to be effected by the application of lime; although the process is not recommended for adoption on account of the large quantity and unsaleable character of the deposit.

The formation of a public road, 40 feet wide, is recommended through the marshes on the north side, under which shall be built a triple culvert of brickwork, each culvert to be 9 feet diameter. This road would afford a convenient communication between the pumping station and reservoirs, and would, it is believed, become a road of much importance to the extending districts at the eastern extremity of the metropolis.

On the north side the low-level sewage is proposed to be raised at Abbey Mills, by mechanical power, to the height of about 34 feet, and will thence flow by gravitation into the reservoirs; and on the south side the whole of the sewage will be similarly raised into the reservoir near the outfall, from a depth of 25 feet.

If it had been possible to have drained the whole of London by gravitation, there is no question that such a plan would have been immeasurably superior to either of the schemes under consideration; but inasmuch as any plan which proposes the relief of the low-lying districts on the banks of the river, and the exclusion of the sewage from the Thames, must adopt mechanical aid for raising the sewage, the extent and economy of such application becomes a question solely for the consideration of the practical engineer. Meanwhile, should the metropolitan drainage be executed in the most efficient and successful manner, our satisfaction must ever be alloyed by the considerations that in addition to the first cost of so great an undertaking, a constant and to some extent uncertain outlay must be incurred in its maintenance; that wide districts will be under bondage to machinery which an accident may at any time derange; and that in the possible future, the great plan now designed for the drainage of the metropolis, may become the means of converting it into a swamp.

Digitized by Google

THE PANAMA RAILWAY.

By V. Wyatt, C.E.

There are but few public undertakings which have so much interest attached to them as the Panama Railway; connecting as it does the two large oceans of the world—the Pacific and the Atlantic—and traversing the backbone of an isthmus which hitherto had been deemed insurmountable; passing to and fro the commerce of the eastern and western parts of the world, and opening up the riches and glories of the Pacific,—this railway bids fair to assume great commercial and general importance. India, Australia, California, British Columbia, and the rich provinces of Central and South America, on the Pacific side, have had a new and direct overland route opened to them by the construction of this isthmus railway.

A casual inspection of the American isthmus and the demands of commerce would seem to dictate that a canal between the two oceans, by which the shipping of the two seas could be interchanged without breaking bulk, would have been a far more useful and commendable work than a railway. So natural is this conclusion that from time to time various and diversified have been the projects for a ship canal between the two seas, and these projects date as far back as the Spanish Conquest. Shortly after Columbus had cruised about and discovered the Central American waters, and when the enterprising Spanish cavalier, Nunez de Balbao, had actually mounted the Andes, and espied, for the first time by a European, the Pacific ocean, more than three centuries since,—the world became convinced of the necessity of some great work on the isthmus. There have been proposed from time to time two different ship canals at Nicaragua—one with a Pacific terminus at San Juan del Tur, and another at Realejo in the Pacific, where the summit level in the former case is 615 feet above the sea, and in the latter about 212 feet. The latter route is somewhat circuitous and uncertain in its data. The Panama crossing of the isthmus has also been advocated, presenting equally favourable features for a canal as it does for a railway. There are no abrupt elevations and depressions; the distance can be made the shortest possible across the isthmus, being only about 30 miles in a straight line; and its greatest elevation above the mean level of two oceans, by careful selection of country, need not exceed the highest point of the Panama Railway, which is only 263 feet, and this summit height being of very short continuance. Then there are the Darien and Atrato routes; the former of which is much controverted, and its assumed data are insufficiently supported by reliable surveys, the summit being stated by one exploring party to be all that the mind can desire, and by another and more recent exploration as beset with mountain ridges and insurmountable obstacles; the latter route (the Atrato) has the objection of lockage up the rivers which descend from the summit each way, and it is very circuitous. There is no difficulty about the level of the two oceans, as the mean tide level of each are identical, the only difference being that the spring tides in the Atlantic are only about 18 inches, whereas in the Pacific they are from 10 feet at San Juan de Nicaragua, to about 18 feet at Panama Bay.

The climate of the coast of Central America and the isthmus of Panama is of the most unhealthy character, and quite unfitted for Europeans. The atmosphere is hot, steamy, damp, miasmatic, and fever generating. The European when he lands on this coast feels his energies relaxed, and his whole system depressed. This was the greatest difficulty the pioneers had to contend with in the construction of the Panama railway. The railway works were of a light character, and would have been deemed trivial in healthy spots; but when the theatre of operations was the isthmus of Panama, then the problem was, not merely to organise men for their work, but how to keep workmen alive in such a pestilential place, continually attacked as they were by intermittent fevers and agues. Every gang of men was being continually broken up by disease, desertion, and excessive mortality. It has been stated that 10,000 men lost their lives in the making of this railway, and that the sleepers in the line count the numbers of bodies buried there; but this calculation, like many other popular rumours, is of course over estimated. It is very certain however, that the company did import on to the isthmus during the time the works were going on more than 3000 Americans, Irish, Chinese, and Negroes, besides the casual supplies of labour which found its way to the works from time to time. The major part of these men fell victims to the isthmus fevers; the Chinese committed suicide to a wholesale extent; many succumbed to their intemperance and irregularities under a tropical sun; and some, including many shrewd Americans, "cleared off," and departed from the isthmus as soon as the seeds of disease or the horrors of the spot became apparent to them. The inconveniences and risk of working in such a climate may be imagined from the fact that the temperature on the isthmus is from 82° in the morning to 90° mid-day Fahrenheit in the shade, and this continued all the year round, with no greater variation than 5° or 6°; and accompanied with this is the unhealthy steam from a tropical rainy season extending over eight months in the year. The sea water in the two oceans adjacent to the isthmus, taken at ten feet below the surface, averages 84° Fahrenheit.

The Panama Railway starts on the Atlantic side from Navy Bay, at a point called by Europeans and New Granadians Colon, and by the people of the United States, Aspinwall, after one of the railway promoters. Colon or Aspinwall town, which has been created by the railway, has a very backwoods-settler look about it, being composed of wooden houses, stores, shops, and hotels, and has only one permanent looking structure, viz., the railway freight and store house, built of stone with an ordinary iron roof of 78 feet span. The American engineers point to this as the very *chef d'œuvre* of engineering. Aspinwall is on the eastern side of Navy Bay, on an almost submerged coral reef, standing only about 3 feet above the Atlantic. It is a wet, swampy, and aguish-looking spot; the rains are incessant; and yellowish-white unhealthy looking faces are visible everwhere amongst the railway employées and residents. Panama is considered a wet place, but in comparison with Colon or Aspinwall, it sinks into insignificance; the railway rain-guage at the latter place showing a register in one rainy season of eight months of 110 inches of rain. England is called wet with an average of 26 inches of rain for the year. Behind Aspinwall is a rotten swamp for miles, the miasma from which salutes the nostrils of the voyager when landing; and he is moreover advisedly informed that a residence of more than 24 hours for a new comer, will probably introduce him to a tropical fever. The old outlet on the Atlantic side for the mule travel of the isthmus was at Chagres, situated to the west of Navy Bay, being at the mouth of the Chagres river; and a never-to-be forgotten place by Californian travellers, who have so often left the bones of their friends on its miserable shores.

The railway after leaving Aspinwall crosses the dismal swamp before alluded to for a distance of 7 or 8 miles ere it reaches terra-firma; it then escapes from this floating bog, with all its rotten, rank, tropical vegetation. The greatest amount of mortality resulted on this part of the line in the first construction; here not only from the unhealthfulness of the situation, but also from a total absence of any properly organised commissariat to supply the men with the necessary and proper comforts; and also allowing the free circulation on the works of the raw spirits so cheaply imported on to the isthmus from the West Indies. Various were the expedients adopted by the American engineers in this swamps to form a foundation for the road, and to economise labour, time and expense. Crib-work (the American term for large wooden boxes, formed of large timber logs, which are loaded with stones or gravel and sunk into position), fragile and temporary trestle-work, and staging on piles. All these methods have rotted and nearly disappeared, as might be expected in a climate where the durability of timber is estimated by months instead of years; and this fragile and temporary work is being substituted, or rather buried up by a filling-in of good, hard, dry, rocky material, with occasional tips of clay to bind the whole together in one mass, enclosing in its bulk the original piled staging and crib-work; the material being obtained from side cutting on the Panama side of the swamp. There is one merit however in the swamp part of the railway, which is that it is the only direct and straight part of the line; most of the rest being very circuitous, and laid out in a succession of serpentine curves, on precipitous sidelong ground.

The clearing of the railway from bush and jungle was attended with considerable risk, having to be done two or three times over during the progress of the works, the growth of vegetation being so prolific here. Now that the line is completed and opened, the clearing is still a work of some expense, and has to be done twice a year by negroes, or the course of the line would be grown up and invisible. In the first attempts at clearing away the

Digitized by Google

jungle, the pestilential insects were an insufferable nuisance to the men; and frequently have they been driven from their work before a cloud of mosquitoes, sand-flies, garropatas, and venomous tropical insects.

From the dismal swamp the railway winds its course tortuously, and in the shape of an almost succession of reversed curves through the summit, and all the way to Panama. These curves are reversed 4°, 6°, and 8°, (which is the American notation for curves of the respective radii of 1432, 955, and 716 feet,) without any straight line to ease the reversal, and not always with the outer rail elevated. The winding course of the line may be conceived of from the fact that the isthmus in a direct line is only about 30 miles wide, but the distance by railway from Colon to Panama Bay is 48 miles. The course is very ingeniously picked out in the vicinity of the summit, taking every available ravine and opening to its assistance; running sidelong on the banks of the Chagres river in dangerous proximity for miles, and turning at times to every conceivable point of the compass, giving the traveller occasional views of tropical luxuriance; taking awful twists and bends to avoid cuttings of 8 or 10 feet in depth; and at last clearing the summit of the isthmus 10½ miles from Panama and the Pacific, with a cutting only averaging about 20 feet in depth and 500 yards long. The greatest grades are 60 feet to a mile, the curves are anything you like, and the maximum elevation to which the locomotive ascends is 263 feet above the mean tide levels of the two seas. Before the railway was explored and constructed, the isthmus had been surveyed by various scientific individuals, who maintained that a less summit could not be found at Panama than about 400 or 500 feet above the sea. But railway engineers soon destroyed the hypotheses of learned explorers (who so often write about nature, but do not attack her,) and by a good deal of pluck and energy, and a small amount of science, brought the project to a practical issue.

The isthmus presents many picturesque tropical beauties between the Aspinwall swamp and Panama. There are the varieties of palm trees, more than twenty in number, with their clusters of scarlet berries; the cocoa-nut tree with its graceful feathery branches; the gigantic flowering tropical lilies and cactus; the plaintain, prickly pear, and gay flowering shrubs and creepers; and the impenetrable jungle or tropical thicket, clothing the ravines with a dense cover of vegetation, and giving to their undulations a gorgeous clothing.

The earthworks upon the railway are but trifling; there are no large cuttings, (the largest being the summit one mentioned above) and no very large banks. The bulk of the material for the banks was taken from patches of side cutting taken at the nearest and most convenient points, regardless alike of appearance or finish. Necessity was the order of the day, and style and order had to succumb. The slopes are not trimmed, or even formed at all like slopes, the cuttings being taken out vertically and allowed to form themselves, and they have formed themselves truly, with the assistance of the tropical rains, into very wild shapes. Nature, here so prolific, however, steps in frequently and clothes their deformities by a tropical covering of vegetation. The tops of the banks are shaved down in too many cases to a nicety, being not more than 10 or 12 feet broad at the top, and cut into and guttered up severely by the tropical rains, for want of a proper sodding. Near the summit this deficiency of embankment gives the line a very dangerous look, and especially so where its slopes are washed by the Chagres river. Diversions of the line, and sacrifice of good alignment are visible in some places where work has been cut down to its minimum, and pushed through at any sacrifice.

The bridges which were first constructed upon the line were of the true wooden, temporary, and American type, having a very stagy look about them, and not intended for inspection by posterity. They were in some cases nothing more than trestle-work of the rudest description, and quite unsafe for trains of more than four or five miles per hour. These, however, thanks to the rapacities of a tropical climate, have gone the way of all that is perishable, and crumbled into dust and tropical mildew. Wrought-iron boiler-plate girder bridges, both for large and small spans, resting upon stone abutments, have been substituted. They are of the simplest character, and have a lean, skeleton appearance. Each bridge is only composed of two ordinary girders, placed directly under each rail, with nothing over them but the common cross-sleepers of irregular lengths, and the rails then spiked to these. No planking, no parapets (although the bridges are frequently placed on very ugly curves, and the train jumps as it mounts them), and the bridges *in toto* resembles an ill-constructed gridiron. The masonry is bold, rough, and good, prepared from a blue granite and whitish freestone which are found on the line, in the execution of which negro labour, as in all other classes of work on the isthmus, is largely employed under white superintendence. These bridges have cost a heavy sum, as they have all been constructed on the wrecks of the old ones, since the opening of the line in 1854, and whilst the ordinary traffic has been going on. The iron bridge over the Chagres river, about half way across the isthmus, is the largest and most important work on the line; it has six openings of 100 feet span each, spanned by as many pairs of boiler-plate girders, arranged in this example to form the parapets, with small cross-girders, and upon these last the longitudinal timbers are fixed to carry the rails. The whole, however, is left grid-iron shape, without planking or finish. It is adapted for a single line only. The upper sides of main girders are curved, which gives to the upper lines of the bridge a wavy and unpleasing appearance.

The permanent way is of the roughest character; being laid and maintained by negro labour, its correctness as to line, level, and finish may be easily judged. The rails are, however, generally good, and of the bridge-rail section, weighing 68 lb. to a yard. Some short distance of the line is laid with the common Yankee foot-rail, or, as it is sometimes termed in England, the contractor's rail. The rails are fastened to the intermediate sleepers by common spikes weighing less than a lb. each, and at the joints are secured very roughly by a small boiler-plate chair (8 lb. weight) and four spikes. This is the universal American system of fixing rails. The rails might, however, have been slotted at one end, through which two of the spikes pass and secure the rail to the chair, and prevent it from sliding. The bridge rails used here were evidently intended for longitudinal timbers; for there are the holes in the flangesfor the screw-bolts which secure the rails to the continuous timbers. The sleepers now used are of lignum vitæ wood, fetched from Carthagena on the Atlantic side of the isthmus, and cost when delivered 6*s*. each. The sleepers originally used (pine) on the line have wholly disappeared; they only lasted from two to three years. The lignum vitæ sleepers are reported to be of no longer duration than about twelve years. The ballast was omitted from the line almost entirely in its first formation, and now it is not universally used throughout, being put on in patches from time to time, where it is found to be all important to keep the permanent way from being washed out of position by the tropical rains. It is principally formed of broken rock and coarse gravel, both of which are plentiful on the line; it is used sparingly however, the sleepers being generally on the soft material on their underside, with broken rock packed between.

The travelling on the railroad is very slow, averaging not more than ten or twelve miles per hour. The grades, however, are not excessive, not exceeding as above stated a maximum of 60 feet in a mile; but the locomotives are weak and asthmatic, and they frequently stick on these inclines with very ordinary trains, and the passengers sit under a broiling tropical sun at the bottom of a cutting, with only an inch board intervening between them and the sun, frequently for an hour together. This is not very pleasant when each passenger pays 5*l*. 3*s*. for the fare to cross the isthmus, and 6*d*. per lb. for all his luggage over 50 lb. weight, which, with something like an ordinary amount of luggage, comes to about 2*s*. 6*d*. per mile per head. The black negro engine-drivers too take a long time to pull up at an intermediate station, swinging backwards and forwards in its vicinity for about a quarter of an hour, like the pendulum of a clock. The locomotives and carriages are of United States build and fashion, only a shade worse. There is the bull-whistle to the locomotive, with its funny little wheels in front on a bogie frame, turning on a swivel-joint, and its broad-topped ugly funnel for wood-burning. The carriages are common and dirty, with no double casing to the top to screen the intense heat of a tropical sun, Venetian slides for windows, and hard seats. The station-houses along the line are mere palm huts (excepting at Aspinwall and Panama), and their vicinities have a wild uncivilised appearance, with the black, nude negroes hovering about in all the crudities of uncivilised life.

At Panama, the terminus of the line on the Pacific side, the station has no conveniences of any kind for travellers; no offices for washing, refreshment, and other purposes. The traveller from California to the United States often finds himself here in

Digitized by Google

company with some 1000 or 1200 persons, just arrived by a Californian steamer, suffering from tropical disorders, and no means of comfort at hand, not even civility.

The total cost of the line has been about 27,000*l.* per mile, and the engineer-in-chief from the commencement to the present time has been Colonel Totten, an American. The railway pays a dividend of 12 per cent. per annum, with its present undeveloped traffic.

INSTITUTION OF CIVIL ENGINEERS.

Nov. 23.—Joseph Locke, Esq., M.P., President, in the Chair.

The Paper read was "*On the successful working by Locomotive Power over Gradients of* 1 *in* 17, *and Curves of* 300 *feet radius, on Inclines in America.*" By Mr. T. S. Isaac.

It was stated, that the road which had decidedly taken the lead in the United States, in the application of locomotive power to steep gradients, and had been generally the pioneer of improvements, was that extending from Baltimore on the Chesapeake Bay, to Wheeling on the Ohio river, a distance of three hundred and eighty miles, through a region of considerable difficulties, especially in the various ranges of the Alleghany mountains. This company was incorporated in 1827, being the first chartered in America, and a portion of the road was opened in May 1830. At first it was worked by horses, but locomotives were employed as early as August 1830,—prior to the opening of the Liverpool and Manchester Railway. Legislative and financial difficulties prevented the commencement of the western section until the year 1849, and it was not until 1851, or three years previous to the opening of the Sömmering incline, that the great incline over the main range of the Alleghanies was completed and worked by locomotives. This latter had an inclination of 1 in 45½ for eleven continuous miles, and after winding amongst the summits of the mountains for twenty miles, it descended on the western side with an inclination of 1 in 45½ for nine continuous miles. The passage of this mountain chain involved altogether sixty miles of railway, twenty miles of which had a gradient of 1 in 45½, and nine miles of 1 in 50, both worked by locomotive power at a speed of from fifteen to twenty miles per hour for passenger trains, and from ten to fifteen miles per hour for goods trains. The curves were frequently 600 feet radius. Although it was one of the main thoroughfares of American commerce, no extra provision was made for working these inclines beyond increasing the number of engines. The engines had eight wheels, all coupled, the diameter of the cylinders being 17 inches, the length of the stroke 2 feet, and the diameter of the wheels 4½ feet. The engines weighed 24 tons each, and the tenders 13 tons each.

In 1852, difficulties were encountered at two different tunnels, which rendered temporary inclines necessary, in order to accomplish the passage of the trains. This system was frequently adopted when it was required to surmount hills where the tunnels were incomplete, in order to enable the iron and other materials for the permanent way to be delivered along the line. There was a maximum gradient over the Kingwood tunnel of 1 in 10, and this incline was in operation for several months, the iron and other materials for upwards of forty miles of line, and the United States mails, having been conveyed over it by locomotive power. The same engine that was used on the other parts of the line was employed, and it drew a loaded car weighing 13 tons, and a tender weighing 12 tons, or a total weight of 25 tons, at the speed of 8 to 10 miles per hour. Over the Broad Tree tunnel there was a series of zigzag inclines on which the upward motion of the train was alternately reversed, the engine at one time pulling, and at another pushing the cars. There were three of these inclines on the eastern, and five on the western slope of the hill. The total length was nearly two miles and one-third, and the gradients varied from 1 in 18 to 1 in 15½, with a minimum radius of curvature of 300 feet. The ordinary freight consisted of two loaded cars weighing together with the tender 37 tons. Mr. Latrobe, the chief engineer of the line said, in his report for 1853, that as many as fifty cars containing 400 tons and two passenger trains had been taken over this hill in a day by four first-class locomotives; and that during five months there had been no accident involving more than a trifling detention. These two inclines, although unprovided with engines especially adapted for the purpose, fully demonstrated the feasibility of traversing gradients altogether unprecedented by the locomotive alone. The experience gained in working them not only established the fact, that a rise of 300 feet per mile and curves of 300 feet radius could be worked with comparative facility, but seemed to point also to a limiting gradient beyond which it was impossible for the locomotive to go with any useful effect, even for a temporary purpose.

Steep gradients and sharp curves had since been adopted on the Virginia Central Railroad on a more extended scale, and had been in successful operation for upwards of four years. The mountain top incline on this road crossed the Blue Ridge mountains at Rock Fish Gap, in Virginia. It was four miles and one-third long, with a ruling gradient of 1 in 18·87. But on the lower half-mile of the eastern slope, the gradient was 1 in 17·86 on curves of 570 feet radius and upwards, and the minimum gradient on curves of 300 feet radius was 1 in 22·22. The length of the eastern slope was 2·37 miles, with an average gradient of 1 in 20½; and of the western slope 1·89 mile, with an average gradient of 1 in 22·22. The whole distance worked by the mountain engines was 8 miles, over which the average gradient was 1 in 29½. The engines were mounted on six wheels, all coupled and set close, the outer wheels being only 9 ft. 4 in. apart from centre to centre. The diameter of the cylinders was 16½ inches, the length of the stroke was 20 inches, and the diameter of the driving wheels was 3½ feet. A tank was provided over the boiler capable of holding 100 cubic feet of water, and above this there was placed 100 cubic feet of fuel, an additional quantity being stored under the footboard, which was lengthened for the purpose. When supplied with wood and water sufficient for a trip of eight miles, each engine weighed about 24½ tons. The usual weight of a mountain train was 45½ tons, the speed being limited by regulation to a maximum of eight miles per hour. The consumption of fuel was three-quarters of a cord of wood westward and half a cord eastward. Greater loads had been conveyed, but those given were the results of ordinary working. For accomplishing the descent, all the cars were provided with a break to each wheel of sufficient strength to lock the wheel if necessary, and a breakman was stationed at each end of the car. The breaks of two cars were found sufficient in ordinary weather; but when the ground was covered with snow or ice, recourse was had to the air cocks of the engines, and sand was applied to the breaks. The author considered that a judicious combination of these two methods was preferable to the exclusive use of either. There was nothing in the motion of the train itself, except a diminution of the speed to indicate that such steep gradients or sharp curves were being traversed. It had now been in operation for upwards of four years without a single accident.

The author believed that the resistance of the curves had been underrated in America. On the mountain-top incline it was proved that the resistance of the curve exceeded 25½ lb. per ton of engine and train. Mr. Latrobe had calculated that the resistance to traction on a level was doubled by a curve of 400 feet radius; and he assumed 13 lb. per ton as the additional friction of a train on a curve of 300 feet radius, whence the additional friction of the engine, due to such a curve, must have exceeded 49 lb. per ton of its own weight. Two expedients had been resorted to for diminishing this friction. On the Baltimore and Ohio incline, for a speed of ten miles per hour, the outer rail had been gradually raised on a curve of 300 feet radius from 2 inches, the height given by the ordinary formula, to 9 inches. On the mountain-top track inclines, for a speed of 8 miles per hour, the outer rail had an elevation of 6½ inches; and a sponge saturated with oil was kept in contact with the flanges of the two forward wheels of each engine. These expedients had so far reduced the friction on the latter road as to cause no perceptible diminution of speed on leaving a straight portion of the track with a gradient of 296 feet per mile, and entering a curve of a radius of 300 feet having a gradient of 238 feet per mile.

The Virginia Central Company had also constructed a shorter incline about 100 miles further west, which was one mile and a-half in length, with gradients varying from 250 feet to 300 feet per mile, and curves of a minimum radius of 400 feet. Over this incline which had been in successful operation for two years, the common freight engines on eight wheels, four of which were coupled, giving 16 tons for adhesion, had taken a load of 36 tons at a speed of five miles per hour.

The ordinary performances of the engines on the mountain-top track showed an exertion of 181½ horse power, including the engine in the load, or 118 horse power not including the engine;

Digitized by Google

giving, in the latter case, 4·8 horse power per ton of motor, the resistance due to the speed and the gradient being 121·64 pounds per ton.

On one or two occasions, on the incline of 1 in 10 on the Baltimore and Ohio line, the weight of the engine being four and three-quarter times the resistance of gravity and the friction of the load, when the rails were very greasy the engine and train slid backwards with locked wheels from near the top to the bottom of this incline, without damage. The wheels of these engines had chilled tyres, a circumstance which considerably decreased their adhesion. The engines on the mountain-top track with an ordinary train exercised an adhesive power of one-sixth of their weight, and this could always be maintained in the severest weather by the use of a fine clean sand.

In conclusion, the author remarked that there were probably few mountain passes that could not be overcome by the introduction of gradients of 1 in 17, and experience had satisfactorily proved that the locomotive could draw a load nearly double its own weight up such a gradient at a speed of eight miles per hour. The working of the mountain-top track furnished additional evidence to that already gained from other sources, of the superiority of light engines with light loads over heavy engines with heavy loads.

Hall's Apparatus for Working Railway Breaks.—After the meeting, a model was exhibited of an apparatus by which railway carriages were coupled together, so as to render the action of the breaks continuous throughout the train, and thus render it possible to apply three or four breaks simultaneously. A longitudinal square bar was suspended under each carriage, the connection being made by a universal joint coupling. In making up a train, the break blocks of the break vans were screwed up close to the rims of the wheels, and then the coupling was effected, so as to avoid the possibility of slack. The break blocks were so arranged on the carriages that two operated in each direction, so that the carriages might be moved either backwards or forwards indiscriminately; but this was not the case with those attached to the tenders and the break van. The mode of applying the power was similar to that ordinarily in use. There was a worm wheel on the spindle of the handle from the van, working into a cog wheel fast on the longitudinal shaft. On this shaft there was also a screw working in a loose collar, to which was attached the ends of one pair of levers, operating the arm of a lever on a fixed shaft, also carrying the levers to which the blocks were attached.

Nov. 30.—Geo. P. Bidder, Esq., V.P., in the Chair.

The whole of the evening was occupied by the Discussion of Mr. Isaac's paper on "*Steep Inclines in America.*"

It was explained that on the Baltimore and Ohio Railway, the ordinary goods engines had cylinders of 19 inches diameter, with a stroke of 22 inches; they had eight driving wheels, of 3 ft. 7 in. diameter, all coupled. The passenger engines principally employed on the inclines of 1 in 45½ had cylinders of 19 inches diameter, and 22 inches stroke, with six driving wheels, 4 ft. 2 in. diameter, all coupled, and a leading truck, or bogie, on four wheels. Peculiar arrangements were made for facilitating the passage over curves of small radius; the centres of the front and hind wheels were only 11 ft. 3 in. apart, and the intermediate wheels were without any flanches, the springs being so adjusted as to equalise the weight.

It was stated, that the adhesion of driving-wheels had been shown from experience in the United States to be beyond the limits usually assigned. Instances were known where the effective adhesion had been as much as two-fifths of the nominal weight on the driving wheel; it being assumed that this varied much when running, as compared with the actual weight ascertained by the weighing machine when at rest.

On the Cleveland and Pittsburgh Railway, on the 1st August, 1857, a train of fifty loaded waggons, each on eight wheels, and weighing with the engine and tender 800 tons, was drawn up a continuous incline, 2 miles in length, of 1 in 132. The engine weighed 26·8 tons, with only 19·2 tons on the six coupled wheels. The gravity of the entire train would be 13,575 lb., whilst the friction, which could not average less than 5 lb. per ton, would increase the amount to 17,575 lb., or to more than two-fifths of the weight upon the driving wheels.

In making a series of trials for the New York and Erie Railway, Mr. Zerah Colburn drove a train of eighty waggons, each on eight wheels, weighing with the engine and tender 1270 tons, up a continuous incline of 1 in 480, with curves of 1145 feet radius. The gravity being 6000 lb., and the other resistances 8300 lb., the entire resistance was 14,300 lb. The weight on the driving wheels of the engine at rest was 40,500 lb.; hence the adhesion was 0·35 of the insistent weight.

An engine, when on a severe incline, changed its position so much as to alter materially its running condition, which should be provided for in building engines expressly for working inclines.

It was stated, that at the time of construction of the Mountain Top Incline, it was found necessary to place a tank on the eastern slope, on a gradient of 1 in 18·87. During the first two or three summers the ascending trains were in the habit of stopping daily, and the engines were able to start again without difficulty. There was one engine on the mountain on eight wheels, all coupled; the cylinders were 18 inches in diameter, with a length of stroke of 22 inches; the wheels were 3½ feet in diameter, and the gross weight of the engine was 27 tons. This engine had crossed the mountain six times in one day, with a load of 49 tons each time; making the trip in one hour from Turntable to Greenwood, and in one hour and a quarter from Greenwood to Turntable; although it was very rigid, and was not adapted to the curves. One of the lighter engines had taken a load from Turntable to Greenwood in half an hour. Mr. Ellet had published a statement of the cost of working, based on the fuel and oil consumed, and the wages of the workmen. Fuel on the mountain cost two dollars per cord. It was difficult to make a just comparison of the various fuels, and to obtain correct information as to the water evaporated. The same cause that prevented the experiments on the resistance of curves, prevented comparative experiments on fuels, and accurate statements of the water evaporated. At first, pine was used, but oak had been extensively adopted latterly. The effective pressure of the steam above that of the atmosphere usually amounted to from 100 lb. to 120 lb.

It was remarked that whereas on most English railways, the results of experience showed a resistance of 12 lb. per ton gross on a level, yet some of the statements which had been made as to the working of railways in the United States, seemed to indicate a resistance of not more than 5 lb. per ton gross after allowing for gravitation on the incline; whilst the permanent way of American lines was notoriously inferior in all respects to that of the English lines. The first of the results named in the paper showed a traction resistance of about 150 lb. per ton gross. In contrast with this it was stated, that on the Great North of Scotland Railway, near Aberdeen, the Kitty Brewster incline of 1 in 59, and full of quick curves, had been worked for the last three years by two tank locomotives, having cylinders 15 inches diameter, with a length of stroke of 24 inches, and four wheels coupled, each 4½ feet diameter, at a steam pressure of 150 lb., the load on the driving wheels being 15 tons, on the leading wheels 10 tons, and the gross weight in working order 25 tons. The trains were started from the foot of the incline. One of these engines could take up nineteen waggons, weighing when loaded about 11 tons each—making a total gross weight of train behind the engine of 200 tons—at ten miles per hour. The greatest load that had been taken was twenty-one waggons, of a gross weight of 230 tons, at 5 miles per hour. The average ordinary train taken up the incline consisted of eighteen waggons, each weighing 8 to 11 tons gross; the total weight being, say 160 tons gross, at 10 miles per hour; but excursion trains of loaded carriages, weighing when empty 5½ tons each, and 7½ tons when loaded, making a gross load of, say 200 tons, had also been taken up. The resistance of the train indicated on the piston, after allowing for gravitation on the incline, amounted to 13 lb. per ton gross of engine, tender, and trains, which contrasted favourably with the estimated traction-resistance of 150 lb. per ton gross on the American incline.

With reference to the influence of curves upon resistance, it had been found that at a speed of 45 miles per hour the traction-resistance was greater by 20 per cent. on a line having curves under one mile radius, at the rate of one curve in 2½ miles, than on a practically straight line.

It was remarked, that the Whitstable branch of the South Eastern Railway, on which there was a gradient of 1 in 30, had originally been worked by stationary engines and rope traction; but as the traffic was intermittent, it had been determined some years ago to substitute locomotive power, and this application

Digitized by Google

had been quite successful. Bury's four-wheel coupled engines, having cylinders 14 inches in diameter, with a length of stroke of 24 inches, the wheels being 4 ft. 6 in. in diameter, were still in use on this branch. Four trucks of coal were taken up the incline of 1 in 30, the gross weight, including the engine and tender, being about 50 tons.

On the Folkestone branch of the same line, which had an inclination of 1 in 30 for upwards of three-quarters of a mile, four-wheel tank engines, constructed on Mr. Crampton's plan, were employed. The four wheels of 4½ feet diameter were all coupled; the cylinders were 16 inches diameter, with a length of stroke of 24 inches; the weight of the engine was 26½ tons, and the pressure of the steam was 120 lb. per square inch. These engines had taken up the incline a load of fourteen carriages, equal to a gross weight of 100 tons, including the engine.

It was believed, that the peculiar construction of the engines and carriages in the United States, tended to lessen the resistance of curves. It was well known, that in New York and in other American cities, the railways were brought into the streets, horse-power being then employed, and that the trains were conducted round the turnings of streets with great facility. As to the cost of construction of American railways, it appeared from official returns, which had been carefully compiled, that in the state of Massachusetts the cost of the principal lines had amounted to 10,599*l.* per mile, or 9489*l.* per mile exclusive of rolling stock. In the state of New York these figures were respectively 11,200*l.* and 9762*l.* per mile. It should be stated that a large proportion of the American railways consisted of single way, and that their cost ranged between 5000*l.* and 14,000*l.* per mile.

The Manchester, Sheffield, and Lincolnshire Railway, with a gradient of 1 in 130 for upwards of 22 miles, was mentioned as a case of a main trunk line, upon which there was a large traffic, necessitating the employment of heavy engines. Ordinary inside-cylinder engines were employed, the cylinders being 18 inches in diameter, with a length of stroke of 24 inches, the wheels being 5 feet in diameter, all coupled. They weighed, when in working order, 31 tons, were worked at a pressure of 130 lb. to the square inch, and would draw a load of forty waggons, weighing 130 tons, independent of the weight of the engine and tender.

The great feature in the paper under discussion was thought to consist in the statement, that two-fifths of the weight of the engine had been obtained as adhesive capability; whereas in this country one-fourth had been considered as much as could be relied on in all states of the rails. On the West Cornwal Railway, loads of about 13 tons had been conveyed up an incline of 1 in 13, for a distance of from a half to three-quarters of a mile. The engine had four wheels coupled, and cylinders 13 inches in diameter. This plan had been considered preferable to the employment of stationary power. On the South Devon line there were gradients varying from 1 in 41 to 1 in 51, with S curves of 15 chains radius. As a practical fact it might be recorded, that the engines would take seven loaded waggons up an incline of 1 in 41 on straight portions of the line, but when they came to curves of 15 chains radius, one of the waggons had to be removed.

It was stated, that on the Lickey incline of 1 in 37½, an engine had been allowed to attain a speed of 30 miles in descending, and it was then brought up in 30 seconds by the application of a peculiar kind of break to the wheels of the engines,

With regard to zigzag inclines for traversing mountains, it was stated that the late Mr. George Stephenson had suggested their adoption thirteen years ago on a line in Spain. Mr. Drane had also recommended that this method of crossing high mountains should be adopted in Ceylon. And more recently, as was well known, Mr. I. J. Berkley, M. Inst. C.E., had carried out the system successfully on the Great Indian Peninsula Railway, for ascending the Bhore Ghaut. It was thought that they were only desirable under special circumstances, and in peculiar positions where it was impossible to make a continuous line except at great cost, or by the introduction of excessively sharp curves.

Probably the steepest gradients in this country, over which a large traffic was conveyed, were on the line between Manchester and Oldham, a distance of 7 miles. For a mile and a quarter there was an inclination of 1 in 48 or 1 in 50. The line was then tolerably level, until on approaching Oldham, gradients of 1 in 30 and 1 in 39 were encountered; and for about a mile and a quarter 1 in 27. This latter incline had originally been worked by stationary power and rope traction; but about five years back the locomotive had been substituted, and no difficulty was found in taking up considerable loads.

In closing the discussion, the circumstances under which steep inclines could with propriety be adopted were considered, and it was remarked that as a mechanical question, there was no difficulty in apportioning the power of the engine to the amount of adhesion required to traverse a particular gradient. But inclines of 1 in 10 or 1 in 17, or even 1 in 40, would only be resorted to from necessity, as such gradients were attended with a heavy cost for working expenses. On a branch of the Stockton and Darlington Railway, where there was an exceptional gradient of 1 in 40, although the traffic was all down-hill, the whole of the receipts of that portion of the line, taken at one penny per ton per mile, were absorbed by the working expenses. If the loads had been up-hill, it was believed that the working expenses alone would have amounted to threepence per ton per mile, and with gradients of 1 in 17, it was thought that this must reach one shilling to eighteen-pence per ton per mile. In fact, it was questionable under such circumstances whether horse-power and carts would not beat the locomotive in point of economy, though of course on a long line of railway it would be most undesirable to introduce a break of guage. It was undoubtedly more economical to employ locomotive power on the Whitstable branch, where the amount of traffic was so inconsiderable; on the Oldham incline, the necessity of preserving an unbroken communication was a justification for the use of the locomotive, the cost of which in such a case must be considerable. On the incline of 1 in 26 near Liege, a perfect system of stationary engines had been in use for many years. The Belgian Government feeling the inconvenience of that system, had abandoned it, and substituted the locomotive; but such was the uncertainty of the power in meeting the inequalities of the incline, that the stationary engines had been again resorted to.

Dec. 7.—Joseph Locke, Esq., M.P., President, in the Chair.

The paper read was, "*A Description of a Breakwater at the Port of Blyth, and of certain Improvements in Breakwaters, applicable to Harbours of Refuge.*" By Mr. M. Scott, M.Inst.C.E.

This communication was divided into four parts, the first referring particularly to the breakwater at the port of Blyth, the second to the theory of waves, the third to the theory of hydraulic construction, including form and methods of building, and the fourth relating exclusively to the author's designs, including his assumed improvements in the construction of breakwaters, which had been suggested by his experience in connection with the work at Blyth.

The port of Blyth was described as being situated on the coast of Northumberland, about ten miles north of the river Tyne. The whole surrounding district was rich in coal, comprising a large virgin field of steam coal in the immediate vicinity. Until recently, a small class of vessels only could trade there, and a great part of the coal raised in the neighbourhood was transmitted by rail to the Tyne for shipment. But a few years ago a company was formed, and powers were obtained for improving the harbour; Mr. J. Abernethy, M. Inst. C.E., being appointed engineer-in-chief, and the author undertaking the construction of a portion of the works. This part of the coast was exposed to a very heavy sea, and gales sprung up with great suddenness. For the length of a mile, the river was exposed to the action of the sea, so that no vessel could then lie in what was now the harbour. Along the seaward side of the river there was a rocky reef, and upon the base thus provided by nature, the breakwater had been erected. The work was originally intended to be, and for a length of 1800 feet was constructed entirely of stone; but a failure in the supply of material induced a change. Mr. Abernethy proposed to employ timber and stone after the manner adopted at Boulogne and at Calais. These views had been carried out in a part of the breakwater which had been completed for some time, which consisted of a framework of timber filled with stone, arranged thus:—First, there was a sole piece resting on the ground. Under each end of the sole, there was placed a block of stone, to which it was fastended at one end by a bolt; the chief object of this bolt being to act as a guide in erecting the frames. Upon this sole were raised two uprights; the one next the sea being supported by a strut from the sole piece.

Digitized by Google

Cross bearers, or half-balks embracing the uprights, carried the roadway above, which was protected by a simple handrail. The frames thus formed, were placed at intervals of 10 feet from centre to centre, and were tied together longitudinally by wailings, two on the sea face and one on the river face, and also by the open planking; the space within which was filled with rubble stone. In the first section this space was triangular, the planking on the river face being on the strut. The object of this arrangement was partly to provide a sloping surface, and to leave the uprights on the river face isolated, opposite the entrance of the proposed docks, for the purpose of destroying as much as possible the swell which passed up the river. In the second section, the exposure and consequent strength required being greater, the planking was put upon the river upright, and the whole space between was filled with rubble, covered with an open flooring of horizontal timbers. The work had added more than 4000 feet in length of the river to the harbour, where there was still water; it not only effectually broke the waves, but acted as a training wall to direct the current, and to confine and intensify within the new limits the action of the tidal scour. The cost of the work had been, on an average, about 10*l.* per lineal foot. The site of this pier was either dry, or nearly so, at low-water spring tides; but as it was to be continued into a depth of 5 or 6 feet at the lowest ebbs, and about 22 feet at high-water of spring tides, it was necessary to modify the plan; and as early as January 1857, the author succeeded in the application of timber to deep-water sections, in the manner hereafter described.

Under the head Theory of Waves, the author availed himself of the labours of Messrs. Scott Russell, Airey, Robertson, and others. He called attention to the two kinds of waves—the one long, low, but extending deep, which was the wave of translation, or wave of the first order; the other kind short, high, and superficial, being the wave of oscillation, or wave of the second order,—and laid down certain principles belonging to each class. He concluded this section by remarking, that if a wave in deep water, when the mass was great and the velocity of the particles small, travelled into shallow water, the quantity agitated was less, but the energy of the motion was increased. Therefore, *cæteris paribus*, the destructive energy was less against the wall vertical from the bottom, than against a wall built with a slope. When the foreshore caused a wave to break upon the wall the destructive effect was greatest. Waves would be broken by any slope having an inclination of less than 45°, but from that angle to the perpendicular, the wave would not be broken, unless it was nearly upon the point of breaking when it reached the slope.

In the third part, under the head Theory of Work, including the theories of form and of construction, the published views of General Sir Harry Jones, Sir William Denison, Prof. Airey, Captain Vetch, &c., were freely made use of; and it was remarked, that when waves could be reflected they ought not to be broken, and that when, from shallowness of water, the wave must break, the operation should be spread over the largest surface, and over the longest time possible. It was desirable, if practicable, so to direct the water, that the force of one portion should tend to neutralise the destructive energy of another portion; it being better to effect the object of stilling the water, by changing the direction, than by absorbing the force of the water in motion. The first condition would be fulfilled by a vertical wall, and the second by a slope. The third was more difficult of attainment. Under the term vertical wall might be included steep slopes, say from 60° upwards. It was thought, that as the vertical face in deep water did reflect waves, the seaward face of breakwaters, especially near the entrance to a harbour, should be built nearly vertical; for should it be a slope, the risk to a vessel approaching the entrance would be increased. With regard to the inner, or harbour side of the breakwater, it was obvious that a vertical face was the best; inasmuch as the work then constituted a valuable quay, alongside which ships might lie to load and unload passengers, cargo, or stores, whereas in the case of a slope, no vessel could approach. With regard to slopes the author considered the true principle to be, that they should be employed only for the purpose of directing or guiding the waves to neutralise one another. This he sought to effect, at least to some extent thus: first, the slope formed of timber was not to join the ground at the foot; there was to be no toe to be injured, but a space through which the water would freely pass. Secondly, the surface of the slope, instead of being continuous, was to have horizontal open spaces, like a gridiron, through which part of the water would fall in its passage upwards, and part on its recession.

The combination of vertical wall and slope, as carried out at Alderney, at Holyhead, and at Portland, was then alluded to, and it was believed that as, even during a very heavy sea, there was but little agitation at the depth of 15 feet under the surface, this section would present nearly, if not all, the advantages of a vertical wall carried up from the bottom of the sea. The quantity of stone used in these works was however very great, so that there were many situations where that method of construction would be inapplicable. There were other disadvantages attaching to this form. First, these breakwaters were not available as quays. Secondly, the seaward profile was such, that the waves must break upon the wall with all their violence, and hence the weight of material and the nature of the work necessary to resist such a shock were no criterion of that required in a vertical face, from which the waves were reflected, and against which they did not break.

The subject was next investigated under the head Theory of Construction—Stone-work, and it was argued that the faces of works exposed to the sea should either have their joints sealed, to prevent the entrance of air, or the work should be so open as to allow the air to pass out with facility. Continuity of face was most important in breakwaters, particularly with vertical faces, for without this the strength of the work, as a whole, would be dependent upon, and be measured by, the power of resistance of the weakest part. Hence arose the necessity of exercising great care during the construction, as the displacement of a single stone might lead to the destruction of the whole work. The author knew of no case on record of a breakwater being carried away or being overturned bodily; and therefore the question was not so much the strength as a whole, which could readily be calculated, but the action of the sea upon an individual portion, which could not be calculated. And if this obtained as regarded the finished work, for the same reasons the danger during the process of construction must be great, especially in the case of a vertical wall.

The fourth section of the Paper was occupied with a description of the author's improvements in the construction of breakwaters. He divided these works into two classes—those intended for deep water being wave reflectors, and those for shallow water being wave breakers. Excepting what was called the wave screen, the reflectors and breakwaters were of a similar character, consisting of a timber casing filled with stone. The stone hearting constituted the power to resist removal as a whole, and the timber facing secured the stone from being disintegrated or carried away in detail, so that if the work was moved it must be bodily. Further, the work was so connected together that each part supported its neighbouring portions;—and there was no tie between the work and the ground. It simply rested on the surface, and the stability depended wholly upon its weight. Other leading features of this arrangement were then noticed, and it was stated that the lower tie would accommodate itself so perfectly to an uneven surface, that the erection might proceed on sand and clay, as well as on rock—on broken as well as on even ground, almost indifferently. The manner in which the round ends at the entrances to harbours were constructed was then described; and it was shown that the planking was arranged like basket work, by which both strength and elasticity were obtained. It was said that the work was not liable to be breached during erection, and that this had been proved at Blyth, where the stone wall had been repeatedly damaged; but the new construction had remained uninjured, although exposed to heavier seas. The frames were put together complete on shore, and were then floated to their place; and it was remarked that the 9 or 10 lb. of oil per cubic foot used in preserving the timber, materially reduced the floating power; so that it was found by calculation for a depth of 10 fathoms, supposing the whole of the timber to be immersed, the total buoyancy would only be 15 cwt. per foot run; but as the timber was not wholly immersed, there was no buoyancy. At half-tide, when standing on end, each frame would have a weight or downward pressure equal to 8 cwt. to sink it. The timber work when finished would have a downward pressure of 25 cwt. per foot run. Thus, it appeared that the weight to be lifted was but little, and that the frame in position could easily be made to gravitate sufficiently to steady itself until secured. In the direction of the length of the breakwater, the frames were kept parallel by sliding ties, which were simply balks of timber with chocks between them, embracing two frames, and being secured together above water, they were slid down to the bottom. Various other details were

Digitized by Google

then given of the mode of carrying on the work under this arrangement, and it was remarked, that the systems pursued at Dover, Alderney, Portland, and Holyhead, did not appear to secure rapid execution; whilst, in illustration of what could be done by this plan, although of course on a comparatively small scale, it was mentioned, that of the work at Blyth 130 lineal feet had been erected in five days.

With regard to the power of the work to resist waves, it was stated that, in the section for a depth of 10 fathoms, the stability was double the greatest force which could be brought to bear upon it. To afford protection to the footings of a wall, or to the toe of a slope of stone in the recoil of breaking waves, a screen had been designed, the construction of which was explained.

In reference to the questions of durability and cost, the author was of opinion that properly prepared timber would last twenty years, and that the section of a depth of 10 fathoms would cost completed about 70*l.* per lineal foot; whereas the stone breakwater at Alderney was said to have cost 190*l.* per foot, and that at Portland 150*l.* per foot. This difference in first cost was so great as to leave, it was considered, an ample margin for the renewal of the timber when it decayed. The manner in which this renewal might be effected was then described.

Finally, it was shown that even if the new arrangements were regarded merely as a means for forming the backbone, as it were, of a more permanent structure, it was the best and cheapest way of attaining the object desired; for viewing the timber only in the light of a temporary staging, the following were some of the advantages claimed for the system—rapidity of execution; a good staging from which to build the stone facing; and the rubble hearting, having been exposed to the sea for years, would be thoroughly consolidated, and form an impenetrable backing.

The author then proceeded to describe the method proposed for completing one form of the permanent work. There were some peculiarities in the mode of setting the face blocks, the objects in view being mainly two; first, for affording increased facilities for handling heavy masses, and secondly, to place within easy reach of the divers, the means of moving the stone in every direction, without the necessity of communicating with anyone above water. This was effected by a system of hydraulic and other machinery, which was then described in detail, for moving masses weighing 25 tons each in six different directions, either down, up, forwards, backwards, to the right, or to the left.

In commencing the discussion, some extracts were given from the Report of the Select Committee on Harbours of Refuge; the tenor of these observations was, that of the three modes of construction of piers brought before the committee, that of tipping the material as "pierre perdue" was that most generally employed, and had hitherto proved most successful. From these passages it appeared, that the general opinion was not favourable to the building of nearly upright walls for piers projected into the sea. It was however contended, from the experience of some years at the Harbour of Refuge works at Dover, that by the use of improved machinery, and by the employment of helmet-divers instead of men in diving-bells, large block work could be accomplished almost as easily, and nearly as quickly, as above the water line.

The machinery for the proposed modification of the present system, was described to be,—having a powerful stage consisting of trestles, as at Dover, or by substituting for timber, cast or wrought iron tubular uprights, with the upper extremities made to slide in order to level the stage in case of the subsidence of the feet. Trussed beams supported the rails for the travellers carrying the steam boiler and engine, with the air pumps for supplying the divers: and for lifting and laying the blocks, to which it was proposed to give very much increased dimensions, such as 15 feet long by 10 feet wide and 6 ft. 8 in. deep; which, if made of brick and cement, would weigh about 50 tons. It was contended that two thousand of these blocks could be laid during each year; and an advance forward of 900 feet per annum of a pier whose total sectional area was 3082 superficial feet; and this with brick and cement blocks at a cost of about 180*l.* per foot lineal; if of rubble stone blocks and cement about 110*l.*; and if of concrete about 101*l.*

If smaller blocks were used, the plant and machinery might be reduced in bulk and cost, and even still greater progress might be made; an instance of this was given by allusion to the pier now being constructed in Rye Bay, of concrete blocks weighing 10 tons each; up to the present time, it had perfectly resisted storms from the south-west, to which it was much exposed.

The further consideration of this subject was then adjourned until the evening of Tuesday, January 11, 1858, when it was hoped the members and visitors would come prepared to discuss this interesting question.

After the meeting, Mr. C. Defries exhibited and explained some specimens of his Improved Railway Carriage Roof Lamps.

Three objects were sought to be accomplished in these lamps. First, by admitting cold air into the burner, thus preventing the oil from boiling, the overflowing of the oil in the glass, so common in other lamps, was prevented. Secondly, a simple method of fixing the glass was adopted, so that by having a stock of glasses at different stations, a broken one might easily be replaced; instead of, as at present, it being necessary to send the damaged lamp to the repairing shops in order that a new glass might be soldered in. Thus a much smaller stock of lamps would be required, and less expense would be incurred for repairs; in addition to which, the chance of breakage in the transit from the stores, would be entirely removed. Thirdly, the interior of each lamp was made in one piece, instead of three or four pieces, as customary. This tended to increase the light, which was remarkably clear and brilliant.

Annual General Meeting.

Dec. 14.—The Report of the Council for the past Session, which was read, commenced by regretting that there had not been a general resumption of works of public utility and of private enterprise in the United Kingdom; a large proportion of the professional engagements being still in foreign countries, or in the British colonies. In India the suspended works upon the different railways had been resumed, and it was fair to conclude would now be pushed forward with vigour. On the continent but little progress had been made, except in the construction of branch lines. The opening of the Caen and Cherbourg Railway, constructed by Mr. Brassey (Assoc. Inst. C.E.), was mentioned, as on that occasion Mr. Locke, M.P., the President of the Institution, who was the engineer-in-chief of the line, had been raised to the grade of Officer of the Legion of Honour. The line traversed a rich and fertile district, inhabited by an enterprising and industrious race; the total length was 225 miles, and the works comprised about 4500 yards of tunnelling, seventy bridges across rivers, and three hundred and ten road bridges.

The various Spanish railways in operation, or in progress of construction, were then noticed; and it was stated, that in Austria, the Lombardo-Venetian Company, under the able direction of M. Paulin Talabot, had united the majority of the principal lines, with a view to the ultimate formation of one comprehensive system, which would be one of the most considerable in Europe, as it would consist of nearly 1900 miles of railway, connecting Austria, Hungary, and Southern Germany with Trieste and Italy, and extending in an unbroken line from Vienna to Milan, and from the Bavarian frontier to Florence.

In Piedmont, where railways were so early introduced, but little had been done for some time past, beyond completing to the foot of the mountains on either side the Victor Emanuel line, and commencing the herculean task of tunnelling through the Alps. Meanwhile, it was proposed to construct a line of railway along the Cornice road, bordering the Mediterranean, from Nice to join the railway at Voltri and thence to Genoa; for the accommodation of the traffic between France and Piedmont until the Alpine tunnel should be completed. In Portugal arrangements had been made, under the direction of Mr. Fowler (M. Inst. C.E.), by Sir Morton Peto, Bart. (Assoc. Inst. C.E.), for the immediate construction of a main line from Lisbon through Coimbra to Oporto. In Russia, the engineers of the Credit Mobilier of France were pushing forward the vast network of lines comprehended within their scheme; and on the Riga and Dunaburg line, under Mr. Hawkshaw, V.P. Inst. C.E., rapid progress was making by Mr. T. Jackson, the contractor. In the East, the Ottoman railway between Smyrna and Aidin, under the direction of Mr. Edwin Clark (M. Inst. C.E) and Mr. Meredith (M. Inst. C.E.), the consulting and the resident engineers, was being vigorously proceeded with; whilst the line from Cairo to Suez had just been completed by M. Mouchelet.

In the Southern Hemisphere the colony of Victoria might be referred to as making great advances in engineering works. Un-

Digitized by Google

dertakings of considerable magnitude had been designed, some were in progress, and a few were completed. The most prominent of these were macadamised roads, railways, water-works, shipping wharves, piers, and slips for heaving ships out of the water. The railway from Yarra Yarra Bridge to Sandhurst, with a deep water pier in Hobson's Bay for ships of 500 tons burden, was completed and in full activity; although as costly, mile for mile, as the London and Greenwich railway, it yielded a profit on the capital of 10 per cent. per annum. From this line a branch had been opened to St. Kilda, which was found to be of great convenience to the suburban and residential traffic, and a prolongation was about to be made to the Sandhurst railway. The Geelong railway had been opened to Williamstown, and had only been delayed from reaching Melbourne by the non-completion of the Government line to Williamstown. The Government lines required to maintain the intercourse with the distant parts of the colony were in progress, large contracts having already been let. The Yan Yean Waterworks for supplying the town of Melbourne were finished; the water was collected in artificial reservoirs, and was conveyed through a system of pipes 40 miles in length to the town. As the town was not subdrained, the disposal of the waste water was even now a serious question, there being only 4 feet tide in the Yarra-Yarra River, which drained into Hobson's Bay an almost tideless lake. At some future, and probably not very distant period, this would render the question of dealing with the sewerage as difficult as that of London. The deep-water piers and slips at Williamstown were in an advanced state of completion, and would be useful auxiliaries to the commercial marine resorting to Hobson's Bay. The system of macadamized roads leading from Melbourne to Maryborough, Sandhurst, Castlemaine, Ballarat, and other important places, had been completed in many cases under very difficult circumstances, but were now so efficient that travelling was almost as rapid and convenient as on the English roads, before the introduction of railways.

In reference to telegraph matters, it was stated, that the attempt to lay the cable between Candia and Alexandria had for the present proved abortive, in consequence of a severe gale, which rendered it necessary to cut the cable and to buoy it when 228 miles had been payed out in a depth of 1400 fathoms. This proceeding was so successful that the cable was fished up on the subsiding of the gale; but the insulation being apparently injured it was not considered advisable to continue the operations during the present advanced season. Candia, Syra, Chio, and Cape Hellas were, however, successfully connected by submarine cables under the superintendence of Mr. Liddell. Another attempt had been made to establish submarine communication between this country and the United States. The English and American steam-ships, with their respective portions of the cable, commenced paying out about mid-channel, and, after some casualties, the shore-ends were landed; but unfortunately the insulation proved so defective, that no intelligible messages could now be transmitted, and, on account of the advanced state of the season, all further attempts to remedy any defects were adjourned. The cable lost in 1855, and a portion of that lost in 1856, off Cape Spartiventi, Sardinia, had been recovered by Mr. Liddell and Mr. F. C. Webb (Assoc. Inst. C.E.) The Channel Islands were now put into telegraphic communication with the English coast, by means of cables laid by Messrs. Newall and Co., from Portland to Alderney, and thence to Guernsey and to Jersey. A cable with four wires was laid down by Messrs. Glass, Elliot, and Co., from Dunwich to Zandvort, but the communication through it had been delayed by an accident, which occurred whilst endeavouring to repair one of the wires;—and a cable with two wires had been successfully laid from the English coast to Emden, likewise by Messrs. Glass, Elliot, and Co.

At home an important feature in the railway extensions in the vicinity of the metropolis was the Victoria Station, Grosvenor-basin, Pimlico, under Mr. Fowler (M. Inst. C.E.) This site was peculiarly fitted for a railway, as from the previous formation of the roads and bridges, the levels of the rails could be so arranged as to avoid interference by inclined approaches with the adjoining streets or properties, whilst affording extensive frontage upon wide streets at present not encumbered with traffic. The works, including a bridge across the Thames, consisting of four arched spans of wrought-iron of 175 feet each, were now in progress.

One of the important hydraulic innovations of the past year had been the new mode of lifting ships, introduced by Mr. Edwin Clark (M. Inst. C.E.), and which had been successfully applied at the Victoria (London) Docks. The apparatus consisted of thirty-two hydraulic presses with cross-heads and suspension links, similar to those used in lifting the tubular girders of the Britannia Bridge. These presses were arranged in two parallel rows, leaving between them a space to receive a gridiron 320 feet long and 60 feet wide, in a depth of water of 27 feet. By an ingenious arrangement the presses were enabled to act in three separate groups, so as either to act simultaneously upon the gridiron, or to lift one or more points; in order, if necessary, to give a certain extent of inclination to the body which was lifted. It was stated that the original cost of a system of docks of this description would only be about one-fifth of that of ordinary graving docks; the operations of lifting and lowering were very rapid, a vessel of 1000 tons burthen only occupying the docks for about thirty-five minutes; and the facility for making the repairs was very great.

In supplying towns with water the only important work of the past year was at the South Staffordshire Waterworks. The object of this undertaking was to supply the towns and districts of Lichfield, Walsall, Wednesbury, Westbromwich, Tipton, and Dudley, where hitherto there had been a serious dearth of good water. The spot selected by Mr. J. R. McClean (V.P. Inst. C.E.) for establishing the pumping engines was at Lichfield, where (in addition to a large surface supply taken above the contamination of any sewage) by sinking down to the sandstone-rock, and driving a tunnel upwards of a mile in length, an unlimited quantity of pure soft water was obtained. This was raised by a pair of James Watt and Co.'s powerful pumping engines, and forced through a 2-feet main of cast-iron pipes to a single standpipe at Brownhills, whence the water proceeded by gravitation through the remainder of the main, 22 inches diameter, which was laid for a distance of nearly 14 miles, chiefly alongside the rails of the South Staffordshire Railway to the reservoirs of Walsall, Wednesbury, and Westbromwich, situated at the respective heights of 180 feet, 240 feet, and 260 feet above the main at the engines. The total contents of the storage reservoirs was 90,000,000 gallons. The ultimate length of the main pipe would be upwards of 25 miles, and it was given as a remarkable instance of care on the part of the Messrs. Cochrane and Co., the iron-founders, and Mr. Aird, the contractor for laying them, that out of seven thousand pipes only two should have exhibited any defect when laid, and these defects were each remedied within an hour.

The principal papers read during the session were then noticed; and it was remarked that, as usual, the discussions occupied a longer time than the reading of the papers, and would be found to add greatly to the interest of the Minutes of Proceedings.

The members were strongly urged to continue to present copies of scientific and professional works for the library, without which its utility for reference and consultation could not be maintained.

Special attention was directed to a very interesting series of photographs of some important structures in the City of Washington, U.S. America, now in progress or recently completed under the direction of Captain Montgomery Meigs, U.S. Engineers, by whom the views were presented to the institution.

The Washington Aqueduct, the most important, though not the most costly of these works, was intended to supply the city of Washington with water from the great falls of the Potomac. The source was 150 feet above the tide. The aqueduct was a circular conduit, generally built of rubble masonry laid in hydraulic cement. The diameter was 9 feet in the clear; the masonry being 14 inches in thickness. Its fall was 9 inches in 5000 feet, and its discharge at 8 feet depth of water was 67,596,000 American standard gallons in twenty-four hours. The lowest discharge of the river in summer droughts was 63,000 cubic feet per minute; at its highest it was a flood like Niagara. There were eleven tunnels upon the line, of which two only were incomplete. Of the 12 miles of conduit about half a mile remained to be executed. There were several bridges of masonry, including one elliptical arch of 75 feet span, and one single granite arch, segmental in form, of 224 feet span, crossing a ravine 100 feet deep, with rock abutments. A bridge of 200 feet span of iron crossed the creeks between Washington and Georgetown; the iron pipes, 48 inches in diameter, doing duty as arched ribs to support the bridge, and also as mains to convey the water under pressure. They were lined with staves of wood as a protection against frost. The reservoirs had a collective area of about 90 acres of water, and stored up many days' supply. The work was completed except the dam, the second reservoir, the larger bridges, and two tunnels, one of which would be finished during this winter, and the other in July next. The bridges would pro-

Digitized by Google

bably be all completed by the 1st of August, 1859. The estimated original cost of the 7-feet conduit was 1,921,000 dollars; of the 9-feet conduit, 2,300,000 dollars; and the probable cost when finished was estimated at 2,550,000 dollars. The masonry aqueduct was 12 miles long. The pipes to be laid by the Government to the public buildings, navy yards, &c., would cost about 400,000 dollars.

The Capitol of the United States was a building 750 feet in length and 70 feet in height. The centre was looked upon in America as an old building, having been built about thirty years. It was of sandstone. The wings upon which Captain Meigs was now engaged were faced with blocks of white marble, and slightly veined with blue, but not sufficiently coloured to affect the appearance at a short distance. In this building were the Halls of Congress. The Hall of Representatives in the south wing was 139 feet long, 93 feet wide, and 36 feet high. In it the voice of any ordinary speaker was said to be audible, without effort, in every part of the room, and this without regard to the place from which the orator addressed the audience. Its ventilation was satisfactory, and throughout the variable winter there were no complaints of too much cold. The north wing would be occupied this winter. The porticoes yet remained to be erected. The centre building was crowned by a dome, partly of brick and partly of wood, modelled after that of the Pantheon at Rome. The portico of this building was also a copy from the Pantheon, but raised upon a basement with a noble flight of steps in front. The old dome had been removed, and some progress had been made in erecting the new one, which was of iron, 300 feet in height; the diameter of the peristyle being 124 ft. 6 in. The cost of the old building of the Capitol was about 3,000,000 dollars; the new wings would cost between 5,000,000 and 6,000,000 dollars, and the dome nearly 1,000,000 dollars.

The Post-office building was of white marble. The columns were monolithic, from Carrara. The rest of the marble was similar to that in use at the Capitol.

The Washington Aqueduct was entirely under the direction of Captain Meigs, but in the architecture of the Capitol and the Post-office buildings he had the aid of Mr. Thomas U. Walter, who had been associated with him since he took charge of these two buildings. In the heating and ventilating of this building he had the assistance of Mr. Joseph Nason. The works involved a total expenditure of nearly 10,000,000 of dollars. They were now drawing towards completion. The buildings were occupied; the porticoes and the dome remaining unfinished, and some interior decorations were still in progress.

The deceases of the members during the year were announced to have been:—Rear-Admiral Sir F. Beaufort, honorary member; Messrs. R. Garrett, A. Grève, R. Hopkins, A. S. Jee, H. F. Mackworth, and J. Seaward, members; and Sir G. Cayley, Bart., and Messrs. T. W. B. Blakemore, M.P., and J. Hodgson, associates. The memoirs of these gentlemen were given in the appendix to the report. The resignations of four associates were announced, and it was stated that the effective increase during the year (after deducting the deceases and resignations), amounted to 22, whilst the total number on the books was 857 members of all classes.

The statement of the receipts and expenditure showed an increase of receipts and a diminished expenditure, and that there was a balance of upwards of 1000*l.* in the hands of the treasurer. The financial position was in every respect so satisfactory that the council intended to apply a portion of the surplus funds to the improvement and extension of the library.

During the year the second part of volume vii., and the whole of volume xvi. of the Minutes of Proceedings had been published and issued. There now only remained to complete the series of seventeen volumes, extending over twenty-one years, the second part of volume viii. and volume xvii. for the past session, both of which were nearly ready for issue.

The report concluded by congratulating the members on the general satisfactory state of the institution, which to some few still among them had been from its humble beginning in 1818 an object of solicitude. Ample funds, volumes of proceedings printed rapidly, well attended meetings, and crowded *conversazioni*, were the outward signs of prosperity, but they also indicated the greater necessity for increased exertions on the part of all who would insure the permanent prosperity of an institution which had done so much good, and might still continue to be so useful if it was adequately supported by the members of a profession which took no mean part in the labours of the present century.

After the reading of the report, Telford medals were presented to Messrs. J. A. Longridge, G. Robertson, J. Henderson, R. J. Hood, Maj.-Gen. G. B. Tremenheere, and A. Giles; Watt medals to Messrs. G. L. Molesworth and T. S. Sawyer; council premiums of books to Messrs. C. H. Brooks, F. C. Webb, S. A. Varley, R. C. Despard, A. Wright, and J. Brunlees; and the Manby premium in books to Mr. G. L. Molesworth.

The thanks of the institution were unanimously voted to the President for his attention to the duties of his office; to the Vice-presidents and other members and associates of council for their co-operation with the President, and constant attendance at the meetings; to Mr. C. Manby, secretary, and to Mr. Forrest, assistant secretary, for the manner in which they had performed the duties of their offices; as also to the auditors of the accounts and the scrutineers of the ballot for their serviees.

The following gentlemen were elected to fill the several offices on the council for the ensuing year:—Joseph Locke, M.P., President; G. P. Bidder, I. K. Brunel, J. Hawkshaw, and J. R. McClean, Vice-Presidents; W. G. Armstrong, J. Cubitt, J. E. Errington, J. Fowler, C. H. Gregory, T. E. Harrison, T. Hawksley, G. W. Hemans, J. S. Russell, and J. Whitworth, members; and J. A. Ransome and A. Slate, associates.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

An ordinary general meeting of this institution was held on the 14th inst. at Dublin. Mr. M. B. Mullins, President, in the chair.

The paper read was on "Beams and Girder Bridges," by William Anderson, associate, being in continuation of former communications on the same subject. Having in them shown the manner in which the strains in the several parts of uniformly loaded beams were determined, he now concluded the theoretical part of his subject by considering the effect of passing loads. The analytical investigations were illustrated by numerous coloured diagrams, and many of the propositions were proved by means of an accurately constructed model of a lattice beam, the property of Trinity College, Dublin, and lent by Professor Downing for the occasion, the several bars composing it being replaceable at will by spring balances. The theoretical deductions received the most direct proof of experiment. The paper concluded by a recapitulation of the conclusions which had been established.

REVIEWS.

On Telegraphic Cables. Excerpt Minutes of the Proceedings of the Institution of Civil Engineers. Vol. XVII. 8vo. 1858.

On the Mechanical Conditions of the Deposit of a Submarine Cable. By G. B. Airy, Astronomer Royal. 'Philosophical Magazine,' July 1858.

On the Atlantic Cable. By William Gravatt, F.R.S. 'Philosophical Magazine,' July 1858.

Several papers were read in the course of the past year on the subject of Submarine Cables at the Institution of Civil Engineers, of which abstracts appeared in due course in this *Journal*. These papers are now published, by the authority of the Institution, in a collected form, together with notes of the discussions which followed them.

The first of the papers in the volume before us has been rewarded by the Institution by a medal and prize, and is entitled —"On Submerging Telegraphic Cables. By James Atkinson Longridge, M. Inst. C. E., and Charles Henry Brooks." It is to this paper in connection with the engineering questions connected with submarine telegraphy that we shall at present confine our attention. The authors propose to solve several problems of the highest interest and importance to the telegraphic engineer, and investigate, among other things, the tension of the cable, the effect of paying it out at a velocity greater than that of the ship, the effect of currents, and the effect of the vessel pitching in a heavy sea. The paper is accompanied by tables showing numerically the principal results of the mathematical formulæ which are separately investigated in the appendix. Of course reliable formulæ relating to the subject mentioned would be of great value to the engineer, but it may be added that, as the theory

Digitized by Google

of those subjects is comparatively new, no results ought to be adopted without strict scrutiny of the steps of the investigation by which they are arrived at.

Great discrepancies exist among the theories hitherto published. Many of them, including some read at the British Association, and noticed by Messrs. Longridge and Brooks, are so obviously the production of persons who have not the requisite knowledge of dynamics as to be undeserving of serious attention. We observe also a wide divergence between the results expressed in the paper just mentioned and those of the Astronomer Royal, who has also investigated the problem of the sinking cable. In the discussion at the Institution of Civil Engineers, recorded in the volume before us, Prof. Airy expressed (p. 80) his dissent from the principal conclusions of Messrs. Longridge and Brooks. Of course the weight of the authority of the Astronomer Royal should prevail only so far as to occasion inquiry and scrutiny; but the question is not one to be settled by reference to authority, nor is it one even of opinion in the usual sense of the word. A person thoroughly acquainted with the principles and process of a mathematical investigation does not form an opinion of its accuracy; when he has mastered the steps of the reasoning he knows it to be either true or false.

Undoubtedly, the most important problem in the first paper before us, and that on which its conclusions mainly depend, is the Problem 3, on "The general equation to the curve assumed by the sinking cable." The following are the forces taken into account:—1, the weight of the cable in water; 2, the tension acting in the direction of the curve; 3, the tension at the bottom acting horizontally; 4, the resistance of the water; 5, the friction of the water on the cable. The fourth force (the resistance of the water) is assumed to act "at every point of the cable in a direction bisecting the angle formed at that point by the cable and the horizon," that point in the cable being assumed to move in the same direction. This is stated to be the necessary condition in order that the cable may be laid in a straight line without tension. It is however no more than a very inartificial way of stating that the velocity of paying out the cable is equal to the horizontal velocity of the vessel; which is obviously the only case in which the cable could be laid without coils and without tension at the bottom of the sea.

The authors assume also that the curve is invariable in form, and moves uniformly parallel to itself. It is stated that the mode of considering the problem thus adopted "enables it to be treated *statically* as regards the form of the curve."

Here we arrive at the first point on which we have to express our dissent. Assuming everything that the authors have assumed, we consider that nevertheless the problem ought not to be treated statically. There are dynamical considerations which cannot properly be overlooked in discussing the form of the curve. We object to the expression "centrifugal force,' for many reasons, but we do not know any way of briefly stating the nature of the error which arises from treating the problem statically, than by saying that the authors have neglected the effect of centrifugal force. To speak more precisely, the nature of the error may be explained as follows:—Each particle of the cable moves in a curve, and by a known proposition in dynamics the sum of the external forces resolved along the normal to the curve is equal to the quantity usually called the centrifugal force *i.e.* the *vis viva* of the particle divided by the radius of curvature of the curve. Now, this centrifugal force the authors have neglected, and have in effect treated the sum of the normal forces as zero. This error, if there were no other, would in our opinion deprive their investigation of the value of an accurate demonstration.

The next point on which we differ from the authors of the problem in question is one not of a mechanical, but of a purely analytical nature. By a process needlessly complex they arrive at certain differential equations, numbered (3) and (4), involving the tension (t) at any point of the curve, the corresponding length of it, the angle (A) at which its tangent at that point is inclined to the horizon, and the coefficients of resistance and friction. Eliminating t between these two equations, a differential equation to the curve is obtained. It is clear that in this equation A must be a variable. But in integrating it A is treated as a constant. It need scarcely be added that the result obtained is erroneous.

One particular case of this result deserves attention as being that assumed in most of the other investigations of this paper, viz., that when a cable is laid without tension at the bottom, it will descend *in a straight line*. Now, the cable may possibly assume this form, but will not generally do so; in technical language the equation to a straight line is a singular (or particular) and not a complete solution. The case in which the form of the descending cable would be a straight line is obviously this—where the resistance perpendicular to that line is equal to the effect of gravity resolved perpendicularly to that line. Such a case might happen, because whatever the weight of the cable, the resistance may be varied to any extent by varying the velocity of the vessel. In such a case there would be no deflecting forces, but in all others there would be, and the form of the cable would therefore be a curve.

Before leaving this subject we may remark that the conclusion arrived at by the authors in Problem 3, is directly opposed to the conclusion at page 9 of their paper; for there it is stated that "there is no reason *à priori* for concluding that the line of the cable is straight. Indeed, a little consideration leads to an opposite conclusion." The argument which follows is a strange jumble of statical and dynamical ideas, which we do not propose to analyse, but merely notice the discordance between the paper and its appendix, as an illustration of the evils of joint authorship.

In Problem 4, the object proposed is to ascertain "what are the relative velocities of the cable and of the paying-out vessel requisite to reduce the strain or tension to any given amount, and what will be the consequent waste of the cable." Here again, as it seems to us, an error occurs which entirely vitiates the conclusions arrived at. At page 36 it is assumed that when the velocities of the ship and the cable differ, the friction along the cable varies as the square of the velocity of the ship only. But it is clear that the friction depends on the velocity of the cable also; it is the *relative* velocity with which the cable passes through the water which determines the friction.

We have found it convenient and conducive to perspicuity to arrange our remarks in an order not corresponding to the order in which the problems occur in the paper under review, and to examine first the problem which is most important. We proceed now to consider Problem 2, which is founded on the consideration that "if a rod of any material heavier than water is placed in water in an inclined position, it will be found on letting it go that it does not sink vertically, but moves diagonally downwards to the lower side. In fact it runs down an inclined plane between the vertical and its own direction" (p. 6). Certain equations for the motion of such a body are then given. They suppose the body to be a small plane disk not subject to any forces but gravity and the action of the water. They suppose further, that if the body be placed obliquely in water it will descend, moving parallel to itself, and every part of it moving with uniform velocity in a straight line. But the two suppositions are inconsistent with each other, for if the body be subject to no forces but those mentioned, it will rotate, the velocities will not be uniform, and the path of its centre of gravity will be curvilinear. The uniform rectilinear motion assumed in the equations of Problem 2 can only occur when the motion is constrained; and the omission of the constraining forces vitiates the equations and all the deductions from them.

In a corollary to this problem it is attempted to show what will be "the waste of cable when it runs out at a given angle (α) free from tension;" that is, the motion of a small inflexible disk is assimilated to that of a long flexible cable. Of course the equations for the motion of the disk (even if they were correct) would not represent the real motion of the cable, for the several parts of the cable influence each other's motion by their mutual tensions. If it be replied that the corollary is limited to a cable "free from tension," the rejoinder is that such a cable is a pure abstraction. To suppose the telegraph cable to descend free from tension is simply absurd; and we have no hesitation in saying, that the tables given at page 7, showing, in the cases of the "Atlantic cable" and a "light cable," the waste per cent. of cable paid out, are not entitled to the least reliance.

The fifth subject of the paper before us is entitled, "What is the effect of currents and the consequent waste of cable," and relates to Problem 6, "the equation to the curve assumed by a flexible line stretched across a current." In this problem the effect of gravity is omitted, and, if we rightly understand it, the cable is supposed to be lying in a horizontal plane. But it is not explained how the result of such a problem can be applied to the case of a cable acted on by gravity, and descending. If such a cable be acted on by currents transverse to the plane of the ship's

Digitized by Google

motion, the curve will be of double curvature, and a mode of investigation altogether different from that of Problem 6 must be adopted. Some connection seems to be assumed between the form of the curve when the forces are all in one plane, and its form when there are forces acting in more than one plane. But though it is found that the curve of a cable acted on by a current but not by gravity is a common catenary, it does not follow that any relation to the common catenary remains when gravity acts. For instance, it does not follow that the horizontal projection of the curve of double curvature just mentioned is a common catenary. Some curious remarks on this problem are given at page 17, of which the only one of which the meaning is plain, is erroneous. It is said of the form of the cable acted on by a current that "if it is not a straight line, but a curve, it must be a catenary, but it cannot be a catenary without tension at the bottom, consequently the line is not a catenary, but a straight line." It is not correct to say that a catenary cannot exist without tension at the bottom, for by a proper disposition of forces a cable may be made to assume any form whatever, and to be without tension at any assigned point. In Problem 8 the object proposed is to find the form the cable will assume, and the tension, in case the paying-out vessel and the paying out should be suddenly stopped." Here as in a former case, there is an attempt to solve a dynamical problem by reference to purely statical considerations. It is said that immediately on the stopping taking place the curve will begin to rise, and "to assume a catenarian form." What is meant by, beginning to assume a catenarian form? The tension and curve are computed just as if there were equilibrium, but the tension arising from sudden stoppage of motion is obviously very different from a mere statical strain. On the sudden stoppage of the vessel and paying out there would be an impulsive tension or jerk communicated in different degrees to all the parts of the curve, and causing them to move with velocities and in directions which it would require an elaborate dynamical investigation to determine.

The last problem which we shall notice, and that very briefly, is Problem 11:—"To find the variation of motion due to the motion caused by waves." Here again the solution is altogether erroneous. The first equation expresses the angular acceleration of the sheaves of the paying-out machinery due to the tension; and it is assumed that that acceleration is measured by $(T - R)r$, where R is the tension when the ship is at its mean level, T the tension at any other time, and r the radius of the sheaves. The correct expression instead of that just mentioned is $T \cdot r$. In the differential equation for the angular acceleration at any time, the forces acting at that time only ought to enter.

We do not wish to say one word more in condemnation of this paper than is strictly necessary. We give the authors credit for taking great pains; and if they have failed, they have the consolation of knowing that the history of mathematics is full of examples of mistakes in attacking new problems, which have been committed by the most renowned mathematicians. But considering the disastrous consequences which would result from reliance on erroneous investigations of this subject, and considering the warning which Professor Airy had given to the Institution of Civil Engineers respecting this paper, we think we are fully warranted in saying, that the Institution should have subjected the paper to competent revision before issuing it to the world stamped with their approval and authority.

(To be continued.)

Text-Book of Modern Carpentry; comprising a Treatise on Building-Timber. By THOMAS W. SILLOWAY, Architect of the New Capitol, at Montpelier, Vermont.—Boston, U.S.: Crosby and Co. London: S. Low, Son, and Co. 1858.

To use a modern phrase which Lord St. Leonards has introduced, this is a "handy-book," for, without diving deeply into the mysteries of science and mechanical construction, it presents in a concise form the results of a vast amount of experimental and mathematical investigation. For the student who would elaborate the subject, no work is preferable to "Tredgold," albeit it is perhaps getting rather antiquated, except in its more modern guise as edited by Professor Barlow; but the little volume before us (which is of American origin) will be found to contain an amount of practical information which many more ambitious-looking volumes fail in supplying. It may be presumed that the author—who appears to be a man of some professional experience, since he was architect to the new Capitol at Montpelier, Vermont—would necessarily resort in some degree to European precedents, but though this has certainly happened, he gives the reader the benefit of transatlantic experiments also; and some of the particulars thus gleaned have doubtless stood the test of time in a country in which timber is so abundant a material, and one entering so largely into the requirements of every-day life. The portion of the treatise devoted to building-timber, states an average of results arrived at through numerous experiments and much observation. The authorities on the subject are many, and the field wide; but in the few pages allotted to the subject, the writer seems to have condensed the most instructively practical portions of the works of Hutton, Barlow, Du Hamel, Perronet, and many other writers both in Europe and America. A copious "glossary" which is appended to the book has evidently been compiled with considerable care, and, as the definitions are usually amply explained, it will be found essentially serviceable. There is also a goodly number of engraved illustrations which do their part towards the completeness of the whole.

The subject of carpentry is divided into—the nature and properties of timber, the different kinds of timber in use, instructions as to felling and seasoning, the preservation, durability, and strength of timber, with rules for determining its tensile, cross, and compressive strength. Several elementary problems in geometry are next introduced, and the general topic is then resumed by a consideration of the equilibrium of strains on timber, the various modes of scarfing, and the construction of floors and trussed beams. Some excellent hints are given on the framing of roofs, and amongst matters more cursorily touched upon, are domes, bridges, arch centering, and iron work.

Speaking of *American timber*, the author says—

"There are but five kinds of wood in common use for carpentry in this country. These are spruce, pine, oak, hemlock, and chesnut.

"*Spruce*, (Abies) is indigenous to the colder parts of North America, where it grows in great abundance. For most qualities which constitute good framing timber, it is excelled by no other wood in use.

"There are two varieties, which are familiarly known as black or double (Pinus niger) and white or single spruce (Pinus alba). Of these the black is of most value; it being much tougher than the white, and may be procured in much larger sticks. The foliage of this variety is darker and heavier. The white spruce is of a comparatively small growth; but the wood may be worked much smoother than the other variety. Spruce-wood, when seasoned, is of a clear yellowish white, the annual rings being distinctly marked by a darker tint of the same colour, and having a silk-like lustre. A cubic foot, when seasoned weighs thirty-one pounds and a half. It shrinks in seasoning about a seventieth part of its dimensions, and loses a fourth of its weight.

"The principal defects of this wood are its liability to twisting and splitting in the sun, and its tendency to decay in all damp situations; but, where due attention is paid to these points, and proper care is exercised to prevent the exposures named, little else need be done to insure the permanency of work composed of this wood.

"*Pine* (Pinus) is next in value as material for a frame. Of this wood there are many species. The family (Conifera) to which it belongs is large, and comprises all that ranges from the most compact and hard spruce to the softest white pine. But two kinds, however, will claim our attention; the others, as framing-timber, partaking largely of the nature of spruce. Remarks relating to that wood may be applied with nearly the same propriety to all the harder varieties of pine.

"The two varieties most in use are known as white pine and Carolina pine.

"*White Pine* (Pinus strobus) abounds in all the northern portion of the United States, and is the tallest of our native trees. It is remarkable for the straightness of its trunk, which is often found a hundred feet high entirely clear of limbs. The whole tree frequently attains an altitude of two hundred feet. It is the same as that known in England as Weymouth pine. In forests, all excepting the top branches decay early; and these, being above all other trees, make it conspicuous as far as it can be seen. Pine is of rapid growth, and, in favourable situations, increases an inch in diameter and two feet in height in a single year. The bark of trees which are less in diameter than fifteen inches

Digitized by Google

is very smooth, and of a bottle-green; being, through the warm season, covered with an ashy gloss.

"The color of the seasoned wood is a brownish white. A cubic foot weighs twenty-four pounds and three-quarters. Its decrease of dimensions in seasoning is slightly more than spruce.* It has little tendency to warp or twist; and, for such parts of a frame as are liable to be exposed to dampness and continued wet, it is preferable to spruce. The wood being softer it is more liable to indentation at the joints; and, being less stiff, it is not for general purposes entirely equal to spruce. As a whole its average value for framing purposes may be considered as nine to ten.

"For finishing-lumber it excels all others, and sustains the same relation to joinery that spruce does to carpentry. None is better calculated to withstand the effects of the sun and weather than this; for with the exercise of proper care in seasoning, and reasonable protection afterwards, it will retain its natural strength and vigour as long as the best of oak.

"*Carolina Pine* (Pinus australis) is in most respects entirely unlike the wood last described; being very compact, and thoroughly saturated with a resin or pitch, which is remarkable for its intense fragrance. It grows in great luxuriance in all our states south of Virginia, and is familiarly known at the north as southern pine. Timber of almost any reasonable length and dimensions may be easily obtained. The wood is seldom cut up into small joists; but when not sawed into large framing-timber, it is used for planks and floor boards; the solidity of the wood, and the fineness of its grain, making it of great value for the purpose last named.

"In all dry situations it is exceedingly durable; but in wet or even damp places it loses its vigour, and soon moulds and decays. Its tensive strength, compared with oak, is nearly equal, while its weight is much less. This quality, added to its peculiar stiffness and resilience, has of late years made it a rival of oak, where a lighter and yet solid wood is required. It is, however, very brittle, and liable to fracture by a sudden blow or concussion; making it inferior to oak where toughness is needed.

This wood when newly planed is a rich yellow; the resinous parts giving it a finely variegated appearance. The average weight of a cubic foot, when seasoned, is not far from thirty-eight pounds and a quarter. It decreases a fifth of its weight in seasoning, and a sixty-fifth of its dimensions; shrinking something more in the direction of its length than either of the other woods in common use.

"*Oak* (Quercus) is a wood, like all others, existing in many species. Only two, however—those commonly known as white oak and yellow oak—are in general use for building purposes. It is a native of temperate climates, and is found in great perfection and vigour in the United States, from Virginia (the northern limit of the growth of Carolina pine) to Canada line. The wood is very durable when kept immersed in water; and while remaining in a perfectly dry situation it has lasted more than a thousand years. When subjected alternately to the action of water and air, together with more than ordinary warmth, it is subject to early decay. Oak-wood is hard, yet elastic and tough. Its texture is alternately porous and solid; the porous sections being the lighter coloured portions of the annual ring. The wood of young trees is much tougher than that of old ones, and is more difficult to work. That of old ones is often quite brittle; while at the same time in many other respects it appears to retain its natural qualities. It is the case with oak as with all trees—that the wood taken from the body and large limbs is stronger than that taken from the small branches. The sap is possessed of a peculiar odour and taste. It contains gallic acid; and, in consequence, turns black or purple when brought in contact with iron.

"The color of the wood is a whitish brown in the white species, and a yellowish brown in the yellow. A cubic foot, when dry, weighs forty-eight pounds. It shrinks in seasoning a thirty-sixth part of its dimensions, and loses a third of its weight.

"For many purposes—such as strengthening-pieces, keys, trenails, &c.—oak is indispensable; though of late years as a general framing timber it has been little used. For the first two centuries after the settlement of this country it was employed almost to the entire exclusion of other wood; but spruce and pine have gradually supplanted it, till now a new piece of oak framing is but seldom seen. When used to any great extent it is for open timber-roofs of churches, or something of the kind. The natural beauty of its selected wood for a rich finish-lumber, and its great strength and durability as a framing timber insure the usefulness and value of the 'monarch of the forest.'

"In addition to the foregoing, the two next in value are those familiarly known as the black oak and the live oak. The former is nearly allied to the yellow oak; and is, in many respects, of equal value. Live oak is principally used in ship-building. The wood is nearly identical with white oak; but the nature and habits of the tree tend to produce only small and very crooked timber. For the various purposes, however, for which the timber is used it is an important member of the Quercus family.

"*Hemlock* (Canadensis) is often used in the cheaper kinds of carpentry, It is indigenous to nearly all places which are favorable to the production of spruce and light pines. In dry situations, when the wood has been properly seasoned and is carefully protected from the action of the sun, it may be considered as a fourth-rate wood. Its peculiar structure, tending to twistish or cleftish grain, makes it entirely unreliable for large timbers where either tensile or compressive strain is required. It decays quickly in damp situations; and if exposed in an unseasoned state its heart-wood cleaves from the surrounding wood by the action of either sun or wind.

"Considering these tendencies (existing even in the best specimens), it is usually cut into small studding joists or common boards. Hemlock possesses one quality in common with oak and the other hard woods; viz., the tenacity with which it adheres to a nail. An ordinary tenpenny cut nail, if driven into the wood half its length, will part before it can be drawn out. This quality is one of its first recommendations for common or rough boarding, as it firmly holds the nails of shingling, slating, clapboarding, &c.

"The sap is possessed of an intense and somewhat unpleasant odour. It is unfit for use while in an unseasoned state, as it corrodes iron immediately at the part where it begins to project from the wood. The color of the wood is a light brown; and a cubic foot, when dry, weighs twenty-seven pounds. It shrinks in seasoning a little less than spruce, and loses one-fourth of its weight.

"*Chesnut* (Castana) is a wood of great value, and is in most respects nearly identical with oak, which it resembles in color, toughness, and solidity. It is a native of temperate regions, and is usually found growing side by side with its rival. For most purposes for which oak is used, chesnut is of equal value. While exceedingly durable in damp situations, it is equally so in those which are dry; and in places partaking at times of both it is preferable to oak. For posts set in the ground it may be considered good for a service of forty years. Like oak, the grain of the wood is compact; and that of young trees is very tough and flexible: but old wood is liable to brittleness, appearing sound and healthy without, while within it is decayed and rotten. Chesnut contains one valuable quality not possessed by either of the other woods; namely, when once seasoned it is but slightly susceptible of shrinking or swelling. The weight of a cubic foot of the wood, when perfectly seasoned, is forty-one pounds."

On the *preservation of timber* we read—

"Wood is liable at any time to change its nature, and part with its most valuable properties. In all timber, even if well seasoned, there remains a certain quantity of sap and vegetable matter, which, when the piece is shut up in stagnant air liable to be heated in summer, will mould or ferment, and an acid be formed decomposing the wood. In no instance should a piece of framing be so enclosed that fresh air cannot at all times come in contact with it.

* * * * *

"The next consideration is to protect it from the action of alternate moisture and dryness. If a stick of timber be exposed to a continued heat—as, for instance, over a baker's oven—it will in time lose its elastic power, and become brittle. If, on the other hand, a piece of the same timber, in all respects identical in properties and nature, be immersed in water, and remain submerged, it will retain the larger part of its properties for centuries. In fact, if not injured by insects or acids in the water, it may be considered as almost indestructible; but the reverse of this is the case if it be subjected to the alternate action of water and air.

"As soon as a piece of wood is exposed to the action of moisture the vegetable and saccharine matter begins to dissolve; and a

* It is the generally received opinion of carpenters, that all wood is liable to some shrinkage in length; though, in most instances, it is hardly perceptible.

Digitized by Google

slimy coating is formed wherever the solution exists. When exposed to the air this slime ferments; and from it grows a sort of fungus, which lives on the vital parts of the wood itself. A continual series of exposures of this kind soon induces a visible decay, which ends in the entire destruction of the timber.

"Every part of the frame should in some way be protected. No work should, therefore, be placed on or very near the ground where earth can in any way come into immediate contact with it; nor should any be subjected to the direct action of steam or vapour, without being in some way shielded. The artificial methods of preserving timber are numerous. Covering the work with boards is in many instances effectual. Sometimes, however, this is no protection, but, on the contrary, serves to retain moisture that would evaporate if left exposed, as is often the case with the sills of buildings, timber bridges, &c.

* * * * *

"The first step to be taken is to season the timber thoroughly. When this has been done the whole of the exposed surface should be covered with some preparation that will strike into the wood, and, as much as possible, harden the outside. Thus, by closing the pores, the piece is made impervious to the weather.

"A valuable practice for the preservation of timber is to heat it by burning charcoal, or something of like nature, beneath; and while it is in a heated state applying a hot solution of an ounce and a half of corrosive sublimate, or one of aqua-fortis (nitric acid), in a gallon of water. After this is done and the work well dried, it should be painted with the best quality of white lead and oil.

"A thin solution of hot coal-tar and whale-oil is of great benefit to all timber that is to be placed near the ground. If this operation be repeated two or three times, and finely pulverised clinkers from a blacksmith's forge, or the dust made from the scales of iron which lie about an anvil, be sifted upon the timber while the tar is newly put on, it will possess great durability, since wood prepared in this manner is scarcely susceptible of decay.

"Pyroligneous acid, or the liquor that drips from stove-pipes in which vapour condenses, also strong decoctions of soot applied hot, are recommended as good preservative agents. In all framing exposed to the weather, every mortise that can hold water, and their tenons, together with all the wood about them, should have a good coating of one of the preparations first named before the work is put together.

* * * * *

"When a piece of framing is to be permanently exposed to the weather, it should be treated with one of the solutions first described, and then thoroughly painted and sanded. Wood in a proper condition when felled, afterwards thoroughly seasoned, well saturated with diluted corrosive sublimate, and finally kept properly painted and sanded, is as durable as it ever can be.

"One caution it would be well to remember; namely, to refrain from applying paint or any preparation to wood before it is thoroughly seasoned; for, should the outside be coated so as effectually to prevent impenetration from without, evaporation will also be prevented from within; therefore, all moisture that may be in the wood will be retained, and rot the piece.

"Another suggestion is to use timbers as small as the nature of the work will permit. It is a mistake to suppose that large timbers will continue good longer than small ones. We may see an exemplification of this at any New England farmhouse. The light spokes of a wheel will remain sound and strong for years after the tongue of the cart to which they belonged has entirely decayed.

"If a timber is sufficiently strong when first used (the requisite allowance being made for permanent strain), all has been done that prudence would dictate, since no increase of the dimensions of the piece will insure its longer duration. And, finally, it should be scrupulously remembered, that timber will not certainly remain sound because a large portion, or even most of it, is in proper condition, and well cared for. Only so much as is actually protected will retain its qualities; and any part so exposed as to injure the whole stick will as surely injure or destroy the unprotected part. Therefore, the ends of timbers which are built into walls, also all surfaces in contact—as where the side or edge of one stick rests upon another, tenons, in mortises, &c.—should be supplied with air, kept dry, and in every way properly protected."

The following table is furnished as the result of experiments on the *strength of wood:*

"*Experiments on the strength of Woods.*

Kind of Wood.	Length in feet.	Breadth in Inches.	Depth in Inches.	Deflection in Inches at the time of fracture.	Weight in Pounds that broke the piece.	Authorities.
English oak, young tree ...	2	1	1	1.87	482	Tredgold
Oak, old ship timber.....	2.5	1	1	1.5	264	"
" from old tree.....	2	1	1	1.38	218	"
" medium quality	2.5	1	1		284	Ebbels
Green oak	2.5	1	1		219	"
Oak, from Riga	2	1	1	1.25	357	Tredgold
Green oak	11.75	8.5	8.5	3.2	25812	Buffon
Beech, medium quality.....	2.5	1	1		271	Ebbels
Alder	2.5	1	1		212	"
Plane-tree	2.5	1	1		243	"
Sycamore	2.5	1	1		214	"
Green chesnut	2.5	1	1		180	"
Ash, from young tree	2.5	1	1	2.5	324	Tredgold
Ash	2.5	1	1	2.38	314	"
Common elm	2.5	1	1		216	Ebbles
Green witch-elm	2.5	1	1		192	"
" acacia	2.5	1	1		249	"
Sp. mahogany, seasoned ...	2.5	1	1		170	Tredgold
Hond. " " ...	2.5	1	1		255	"
Green walnut.....	2.5	1	1		195	Ebbels
Lombardy poplar	2.5	1	1		131	"
Abele poplar	2.5	1	1	1.5	228	Tredgold
Teak	7	2	2	4.0	820	Barlow
Willow	2.5	1	1	3.0	146	Tredgold
Birch	2.5	1	1		207	Ebbels
Cedar of Libanus, dry.....	2.5	1	1	2.75	165	Tredgold
Riga fir	2.5	1	1	1.3	212	"
Memel fir	2.5	1	1	1.15	218	"
Norway fir, from Long Sd.	2	1	1	1.125	396	"
May Forest fir	7	2	2	5.5	360	Barlow
Scotch fir, English growth	2.5	1	1	1.75	233	Tredgold
" "	2.5	1	1		157	Ebbels
Christiania white deal	2	1	1	0.937	343	Tredgold
American white spruce	2	1	1	1.312	285	"
Spruce-fir, British growth .	2.5	1	1		186	Ebbels
American pine, Weymouth	2	1	1	1.125	329	Tredgold
Larch, choice specimen.....	2.5	1	1	3.0	253	"
" medium quality.....	2.5	1	1		223	"
" very young wood...	2.5	1	1	1.75	129	"
Riga fir	4	3	3		4530	Fincham
Red pine.....	4	3	3		3780	"
Yellow pine	4	3	3		2756	"
Cowrie	4	3	3		4110	"
Poona	4	3	3		3990	"

As we have stated, the framing of roofs is a matter freely discussed, and accompanied with numerous diagrams. Specimens are given either with or without tie-beams, and some in which iron tie-rods, &c. are introduced. Many of them have been carried into execution; perhaps the most noticeable is that illustrated in plate xi., which exhibits the design of a portion of the large trusses supporting the dome of the State Capitol at Montpelier. This was executed from drawings supplied by the author, Mr. Silloway, in 1857; and the trusses, together with the framing of the roof and dome, consumed 80,000 feet of timber. The span is 67 ft. 4 in. between the walls, and the trusses receive no support from below. The principle of its construction it would be difficult here to explain, but, in appearance, it resembles three ordinary king-post roofs (of equal span) combined, the tie-beam of one resting upon the ridges of the other two.

The several tables which are interspersed with the general letterpress, will be found valuable for reference; viz., the comparative weights of various thicknesses of iron—from which it appears that American iron is a seventieth heavier than English—computations of timber-measure, roof scantlings, and the tensile strength of different kinds of wood, as deduced from the experiments of Bevan and Muschenbrock; and the costly works of Rondelet and Belidor have not been examined in vain.

Digitized by Google

The Companion to the Almanack.—London: Knight and Co. 1858.

When, as in the case of the serial before us, a book can point to an existence of thirty-two years, it may be presumed to need no favourable introduction to public notice. Among the higher publications of its class, Mr. Knight's Almanack takes a distinguished place, and the mass of general information on subjects of mathematics, natural philosophy, natural history, chronology, geography, fine arts, public economy, &c., with notes on the recent enactments of the legislation, and public improvements, constitute a useful record for preservation on the library shelf, or for more ordinary reference. Among its contents, we have been accustomed for some years to meet with a well-digested essay on the architecture of the day, founded on a review of the principal buildings which have been completed during the previous twelvemonth, and the mere enumeration of these, with the running comment, is to some extent a chronicle of our architectural progress. Yet it is hardly possible that in a single year any great architectural progress can become demonstrable. It is only when we look back over ten or a dozen years that a comparative estimate can be formed. Nevertheless, inasmuch as year after year witnesses the completion of one or more important works, it is possible in almost a single glance to perceive the reflex of the dispositions and abilities of the age. "When in provincial towns we see municipal buildings, like the town halls of Leeds and Newcastle, erected at a vast cost, and with an unstinted amount of ornament, where a few years back, plain 'serviceable' buildings merely would have been constructed; and when, as in London, we see that the caterers for public amusement raise such splendid and artistically-decorated piles as Covent Garden Theatre and St. James's Hall, and in the same year churches are completed so ornate and so costly as those of Doncaster, Stoke Newington, and Richmond, we cannot but feel that it is an evidence of a growing popular appreciation of architecture as an art; and that, in other words, a building is expected now to satisfy the eye by its elegance, or dazzle by its splendour."

The writer proceeds to remark upon the leading competitions which have attracted public attention, such as the Government Offices, the Wellington Testimonial (the proceedings in connection with which are commented upon with not less severity than truth), the Nelson Column, the statues of Jenner and Havelock, the Guards' Memorial, and that erecting in Westminster in honour of the Westminster scholars who fell in the Crimea; with the statues, at Grantham of Sir Isaac Newton, and at Salford of Mr. Brotherton, M.P., and the handsome Crimean Monument at Sheffield. Among the "Public and Sanitary Improvements," we find reference to—first, the Thames (of course), then the main drainage question, and the proceedings of the Board of Works. Among local topics we find the extensive works for the improved water supply of Manchester, which are now brought almost to a termination, and the city is already supplied from the new source. We quote some other particulars.

"The water is obtained from a 'gathering ground' of nearly 20,000 acres; the reservoirs form a chain of ten artificial lakes, stretching for upwards of 4 miles, near Woodhead in Longdendale, and capable of containing 600,000,000 cubic feet of water. Only the pure water supply is conveyed to the city, the turbid water being stored in distinct reservoirs for mill purposes. The water, which is very soft, is carried 12 miles by means of large pipes and aqueducts to a reservoir at Godley, 8 miles from Manchester; it is thence conveyed to two service reservoirs at Denton, 4 miles from Manchester, whence the city is supplied on the constant-service system. When the works are completed, they will, it is estimated, be capable of furnishing 25,000,000 gallons of water daily. The entire cost has been about 1,500,000*l.* Like the gas-works, these works belong to the corporation..... One instance, that of Bourne, Lincolnshire, deserves special notice (though the works were completed in 1857) as showing how much may in skillful hands be accomplished under favourable circumstances at a small outlay. In consequence of the pollution of the stream from which the little town (of 4000 inhabitants) obtained its water, a company was formed for the purpose of procuring a new supply by means of an artesian well. The well was bored to a depth of 92 feet, and all the necessary works were completed at a cost of 1287*l.* The bore of the well is only 4 inches, and through this 567,000 gallons of perfectly pure water rise in twenty-four hours. No engines or pumps are employed, but the town is supplied at high pressure, so that from the fire-cocks or hydrants placed in the streets, water may be thrown by the natural force upon any house direct from the main, and of course without the intervention of a fire-engine. The houses of the poorer inhabitants are supplied at a charge of one penny a week each."

Churches, as usual, claim a large share of attention. Amongst those in or near London which are noticed, besides the three we have mentioned above, are new churches, at Blackheath, by Mr. Ferrey; Orchard-street, Marylebone, by Mr. P. C. Hardwick; and the iron temporary churches at Islington, Holloway, and near the Victoria Docks. The lists of provincial churches and restorations are very large, so that most of them are therefore only enumerated, without detailed remarks.

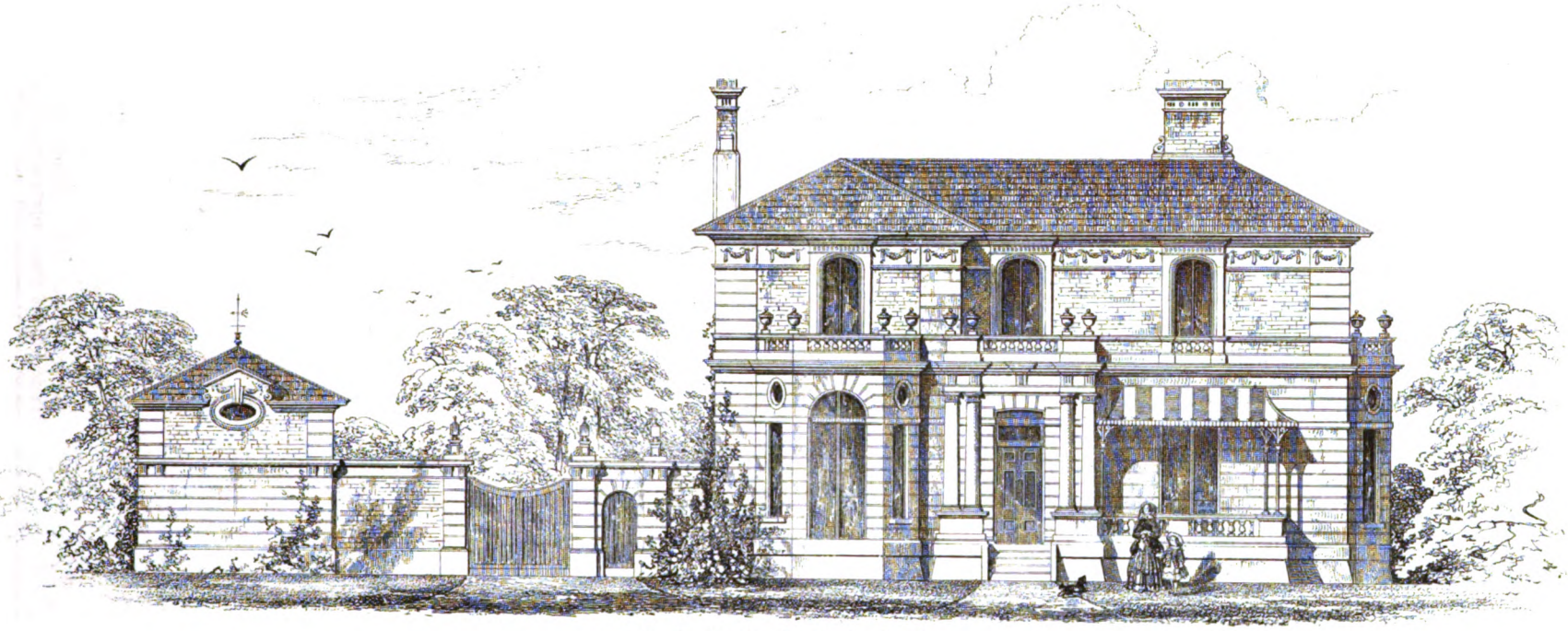
"Church restoration," says our essayist, "seems to be proceeding more rapidly and resolutely than ever: but as almost every kind of reparation, 'beautification,' and extension is now called restoration, it is not always easy to tell what ought to come under the received acceptation of the term. It is impossible for the lover of our old Gothic edifices not to regret the extent to which the process is being carried. Soon, hardly a church or cathedral will remain as it was left by the original architects. The entire surface of a majority of our finest ancient piles has been restored by replacement with modern work,—in our estimation scarcely less destructive a process than would be the restoration of the Theseus or Ilyssus, by having the traces of injury removed by the chisel of a stonemason. Of course it is necessary to repair an edifice that has fallen into decay, it may be even to restore by removing a portion of it; but such restoration should never be carried one line farther than is inevitable, and every part which has been renewed or rebuilt should bear upon its face an inscription to that effect in some conspicuous spot. New work in counterfeit imitation of old is, to our thinking, simply dishonest—the worst of architectural 'shams,' though it be in such marvellous favour with that section of gothicists which is always protesting against shams in architecture."

In discussing the "*Buildings for Public Purposes*," we read—

"The New Palace at Westminster is at length approaching towards completion, so far at least as the building as actually decided on is concerned; but Sir Charles Barry has always contemplated the removal of the present unsightly and inconvenient law courts, the continuance of the design along their site, and the rounding off of the whole by the erection of 'a great entrance gateway with flanking turrets at the corner of New Palace Yard, which would form the public entrance to the building, as distinguished from the royal entrance at the other corner under the Victoria Tower.' Indeed, some such finish seems absolutely necessary to the integrity of the design, and it is most earnestly to be hoped that as soon as the works now approaching rapidly towards their termination are out of the architect's hands he will be empowered to proceed with this part of his task: we shall then have what, with all its faults, will be, beyond dispute, the most magnificent building erected in this country for centuries.....Much has been said of the long time which the works have occupied, and their extreme costliness; but in truth, when the extent and solidity of the works, and the elaborate and sumptuous character of the ornamentation are considered, and it is remembered that every part, from the most massive masonry and the most ponderous iron-work down to the minutest details of the decoration and the fittings, has been executed in the best and most finished manner possible, the wonder rather will be that so much has been accomplished in the time. Probably no other building of similar extent and character has ever been erected in anything like so short a period, and carrying on the comparison with other works, the cost will not seem excessive. What its extent is few very clearly understand. The statement that it covers an area of upwards of 8 acres, comprises 1100 apartments (including the Houses of Lords and Commons, the Central Hall, St. Stephen's Hall, &c., each equal in itself to a building of no ordinary magnitude as well as splendour), above 100 staircases (many of which are of grand proportions), and more than 2 miles of corridors and passages, helps somewhat to a conception of its size. But to understand the enormous expenditure of time, as well as material—and with both, of course, money—which its construction has necessarily involved, it is needful to bear in mind how high it has reached, and how low it has delved, as well as how large an area it has covered; that its towers are among the loftiest as well as the most massive in Europe; and that its foundations, including the coffer-dams and river works, are among the most remarkable combinations

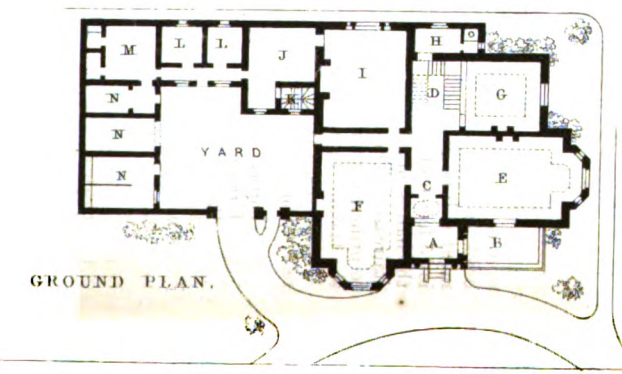
Digitized by Google

Digitized by Google



ELEVATION

10 5 0 10 20 30 40 50 FEET



GROUND PLAN.

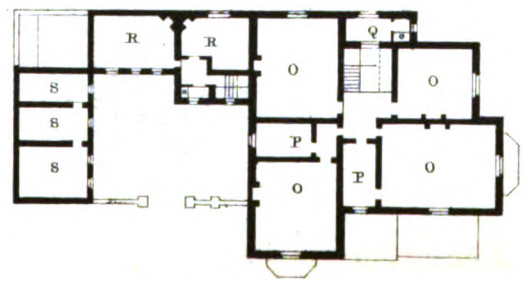
SUBURBAN VILLA.

WOODHEYES PARK, near MANCHESTER

Horace Jones, Archt

1858

5 0 5 10 15 20 25 30 35 FEET



ONE PAIR PLAN

Digitized by Google

of engineering and architectural skill and energy employed in any modern civil edifices; and that to all this has to be added that the artistic decorations stand quite alone in any English work. From the laying of the first stone—the river-wall having been previously completed—in April 1840, nineteen years have not elapsed, and we have very far advanced towards the completion of one of the most magnificent and sumptuous of modern buildings. The entire cost to February 1858, according to Mr. Barry's statement, was, 'as far as the architect is concerned,' 1,768,979*l.*; but as this does not cover all the items, there can be little doubt that it has reached at least 2,000,000*l.* The original estimate was only 707,104*l.* 'But the building to which the original estimate applied, and that which now exists, are two different things.' From the river embankment to the flagstaff on the Victoria Tower, everything has been altered, and the effect of every alteration has been to increase the magnitude, the splendour, and the cost. Some of the alterations were made at the suggestion of the architect, but more originated with the various parliamentary committees and commissions, and some—and those of the costliest, too—were made against the architect's earnest protest; it is therefore manifestly unfair to hold the architect blameable for the increased cost and extended time. We must leave the subject now, however; we have from year to year traced its progress, next year we hope to be able to speak of the building as virtually completed, and to take a more general survey of it, and of its decorations."

Next we have the Leeds Town Hall, the Newcastle Corporation Buildings, and Covent Garden Theatre, respecting all of which, as well as some others which are mentioned, full accounts have from time to time appeared in our pages.

Street Architecture is treated rather summarily (stated to be in consequence of the length of the notice in the previous number); and Engineering works, such as Bridges, Docks, &c., form the concluding subjects of a well written and interesting article. The numerous outline illustrations which are interspersed are great aids to the textual descriptions.

Among other topics of which this volume treats, are a valuable paper on the "Museum of Practical Geology, its Educational Objects;" the "Practical Results of Sanitary Legislation in England;" "The Thames and London Drainage" (to which we shall perhaps again refer); and a description of the several "National Collections of Pictures,"—an interesting article, in which is condensed much information not generally known,—and some others which fall less within our province to notice. Altogether, this 'Companion,' though to our minds scarcely equal to the last, is a very readable and well-digested volume.

VILLA AT ALTRINCHAM, CHESHIRE.

(With an Engraving.)

The accompanying design was recently erected as a suburban residence, with some immaterial alterations, at a cost of 2300*l.*, by Messrs. Bowden, Edwards & Foster, builders, Manchester, from the design and under the superintendence of Mr. Horace Jones, architect, of 16, Furnivals-inn, London. The elevation is in red brick, with Portland cement dressings. The general arrangement will be gathered from the plan. The drawing room, which is 15 feet high, has a coved ceiling, and is well adapted for music; the hall is also lofty and architecturally treated, as also is the staircase. The interior finishings, including the chimney-pieces to principal rooms, are all executed in a style corresponding with the Italian character of the exterior. The site of the house is at Woodheyes, a large park recently laid out for building purposes, near Manchester.

A. Portico.
B. Terrace.
C. Hall.
D. Principal staircase.
E. Drawing room.
F. Dining room.
G. Morning room.
H. Washing closet.
I. Kitchen.
J. Scullery.
K. Back stairs.
L. Larder and pantry.
M. Kitchen court.
N. Harness room, coach house, and stable.
O. Bed room.
P. Dressing room.
Q. Bath room.
R. Nurseries.
S. Man servant's rooms and loft.

ARCHITECTURAL UNION COMPANY.

The honorary secretary of the Architectural Exhibition and Architectural Union Company (Mr. Edmeston) is endeavouring to develope more fully and completely the advantages conferred on the public, and upon exhibitors of manufactures, &c., by the collection of all that is new in building inventions, in the way already put in practice at the Architectural Exhibition, on a small scale, and he has addressed a circular letter to those interested, in which he remarks as follows:

"As the Architectural Exhibition will henceforth be open during the height of the London season, the committee are obliged to incur a rental of more than three times the amount paid in Suffolk-street, and they will therefore be obliged to increase the rentals paid by exhibitors in the materials department, in a corresponding degree. They of course anticipate a largely increased number of visitors, and they have now the great advantage to be united in one house, and to be thus identified with all the architectural societies of London. The Exhibition will also be open for a much longer period than was the case in Suffolk-street. The spaces at disposal will, if against a wall, consist of 3 feet of floor space measured from the wall, and with perpendicular height of 8 or 9 feet, and it is proposed to ask for this a rent of 1*l.* 1*s.* per foot run, or 5*l.* 5*s.* per 6 feet, each exhibitor to fit and set up his own stall or means of exhibition. The space in the centre of one of the galleries may also be appropriated to works of art manufacture, under restriction as to the mode of setting up the articles exhibited, so as not to interfere with the light; the space may be 4 feet wide and with a height of 8 or 9 feet, and the rental required would be 1*l.* 5*s.* per foot, the stall, &c., being set up by the exhibitor.

"From the advantage gained by all exhibitors of materials in the Architectural Exhibition, and which many of them have repeatedly acknowledged to me, I am inclined to think that if the new galleries were filled during a part of the year (say for the months of July, August, September, October, and November) wholly with such an exhibition, it would be found of great benefit to all having anything to make known, and that it might be done at a small cost to exhibitors.

"Thus, let the Architectural Union Company provide a curator, and warming and lighting,—let the Exhibition be rendered as nearly free as possible,—let every encouragement be given to the public to resort to the galleries for the purpose of becoming acquainted with all that is newest and best in building inventions, and let the rent paid be only, say 1*l.* 1*s.* per yard run, or perhaps less for a larger space, and at small cost the very best advertisement will be provided for all inventors. Every architect in London, or from the country who may visit London, would be certain to see the Exhibition, and all would go there for anything they might specially require, or to become acquainted with progress in these matters; while it is quite certain that no one who has much business on his hands can afford to hunt up the different workshops and factories; and those who possess articles of value or of taste can only with the greatest difficulty make known their inventions or manufactures to those who can use them most."

We would specially direct attention to the two last paragraphs. We understand that very numerous applications have been made, and the advantages conferred upon those most interested, at a very small cost, are too obvious to need any recommendation from us; to country manufacturers especially a great boon is offered.

NEW WESTMINSTER BRIDGE.

"Sir,—In the description which appeared in your paper of Wednesday last, relative to the New Bridge at Westminster, it is stated that—

"'Mr. Page had the benefit of Sir Charles Barry's advice in the ornamental accessories of it, in order that its design might be as much as possible in keeping with the architectural style of the new Houses of Parliament.'

"As this statement is likely to produce an erroneous impression as to the extent of my participation in the design of this bridge, I have to request the use of a small portion of your columns to state that, although the usual and remarkable characteristics of the superstructure of the bridge, such as its spacious width, the lowness and easy gradients of its roadway, the proportions of the piers to the arches, and the curve and headway of the latter are in accordance with my design as adopted by the

Digitized by Google

late Sir William Molesworth, the elevation now proposed to be carried into effect is so much at variance with that design as to absolve me from all responsibility in respect of the questionable taste of its details.

"As to the bridge being in harmony with the style of the New Palace at Westminster, I have to observe that the elevation now proposed does not comply with that condition; but it is fair to add that I do not consider such accordance to be necessary, even if it were practicable.—I am, Sir, your obedient servant,

"Old Palace-yard, Dec. 10. CHARLES BARRY."

[The above letter appeared recently in the *Times*.—As far as we are acquainted with the proposed architectural decorations of New Westminster Bridge, we entirely assent to the condemnation of them expressed in this letter. We have seen sectional drawings of cast-iron mouldings intended to ornament the parapet of this bridge; and resembling the profile of Gothic mouldings in stone, but the resemblance is confined to the surface, as these mouldings, instead of being solid, are hollow internally. The taste for cast-iron Gothic has been deservedly ridiculed; the true ground for its condemnation being, as we apprehend, not the mere nature of the material, but the wrong use of it. The mode of artistic treatment which is proper for a material like stone is obviously improper for metallic substances, and of these again, those which are malleable require one mode of treatment and those which are cast another. A few years ago the mere superficial imitation of Gothic forms passed for Gothic architecture, but a purer taste demands not mere mimicry of its forms, but a comprehension of its principles, which have been utterly disregarded in the designs in question.—ED.]

IMPROVEMENTS IN EDINBURGH.

THE designs for the new street extending from the High-street, immediately opposite the Tron Church, to the south end of Waverley-bridge, have been approved of by Sir William Gibson Craig, the referee under the Railway Access Company's Act, and are being exhibited to the public at present in George-street Hall. Messrs. Peddie and Kinnear, the architects to the Railway Access Company, have, as may be seen from the designs in George-street Hall, been very successful in complying with the requirements of the Act, which sets forth the desirableness of preserving as far as possible the character of the buildings in the district through which the new street is to run. At the northern entrance, leading directly from Waverley-bridge, they propose to erect a large hotel of three stories and attics, circular above the third story, and terminating in a high crow-stepped gable. A turret, a balcony, dormer windows, &c., give to the building, which will occupy a considerable space of ground, a very picturesque appearance. As much will necessarily depend upon the aspect which the back of the northern part of the street will present when looked at from Princes-street, care has been taken by the architects to form an irregular sky line by breaking up the portions of the houses seen above Market-street. The buildings in the street itself are considerably varied, both in breadth and height, massed without producing an effect of heaviness, and relieved by the openings to the several closes as well as by variety of architectural detail. The houses are chiefly designed for shops with warehouses or saloons and attics above.

About the middle of the northern side of the street it is proposed to erect a public hall, capable of holding about 600 persons. This, which is to rise two stories above the shop front, is distinguished in the designs by a three-light window and a tall gable. There is no building in the centre of the town really available for public meetings, except the Merchant's-hall in Hunter-square. It is to be hoped that of whatever extent this place of meeting may be, means will be taken to guard against the serious mistake of having only one avenue of entrance and egress. The inconvenience experienced at crowded meetings in the two public halls in Edinburgh is not only excessive, but it points to serious dangers in the event of an accident taking place. The designs for some of the buildings on the south side of Lord Cockburn-street are not yet completed, but a good idea can be formed of the general appearance which it will present. The designs have been carefully prepared with a view not only to utility, but general effect, and give reason to hope that the new street will add to, rather than detract from the fine appearance of the irregular masses presented to the view of the spectator who looks across from the northern side of the railway valley.

COMPETITIONS.

Designs or models are invited for a Monument to the memory of the late Lieut.-Colonel Morris, C.B., on Hatherleigh Moor, Devonshire. It is hoped that between 400*l.* and 500*l.* will be collected; the subscriptions at present amount to 345*l.* The committee will not be held liable to pay for the preparation of such designs or models. The next meeting of the committee will be at the Subscription-rooms, Hatherleigh, on Jan. 20, 1859, at one o'clock, before which day the designs or models are requested to be sent to the care of Mr. Pearse, solicitor, Hatherleigh.

Plans or models are requested of a New Tabernacle at Newington for the congregation of the Rev. C. H. Spurgeon, on land situate near the Elephant and Castle, Newington. Premiums, 50*l.*, 30*l.*, and 20*l.* The drawings to show a plan of each floor and gallery—longitudinal and transverse sections—and elevations, drawn to a scale of 8 feet to 1 inch, and tinted in light brown Indian ink. One perspective view, tinted in like manner, may accompany each design; but bird's-eye perspective views and drawings in frames other than straining frames and glasses will not be received. The building to contain on basement-floor (which is to be 5 feet below the level of the footway) school-rooms, 12 feet high, for boys and girls, and lecture hall to seat 800 persons. The chapel above to seat 3,000 persons, and standing room for not less than 1,000, and with not more than two tiers of galleries; each sitting to be not less than 2 feet 6 inches by 1 foot 7 inches. Gothic designs will not be accepted. The plan of the Surrey Music-hall has proved to be acoustically good, and will be decidedly prefered. Provision to be made for baptistery, six vestries, waterclosets, urinals, &c. The total cost, including architect's commission, warming, ventilation, lighting, boundary walls, fences, paths, fittings, and every expense, to be about 16,000*l.* Each architect to state the commission he will require on outlay—such commission to include all expenses for measuring, superintendence, &c. The architects competing will be requested to undertake the task of acting as judges, and to award the first and third premiums. For this purpose the Committee will require the name and address of each competitor to be forwarded to them, per post, on the 1st day of February. The second premium to be awarded by the Committee; and no architect to select his own design. Designs to be sent by the 31st inst.

Designs are invited for the proposed Manchester Assize Courts, Lodgings for Her Majesty's Judges, Offices, Lockups, and all other accommodation which may be necessary or convenient for carrying on the civil and criminal business usually transacted at courts of assize. A premium of 250*l.* will be given for the best design, 150*l.* for the second best, and 100*l.* for the third best. The various buildings are to be erected on a plot of land, part of which was recently the site of Strangeways Hall, situate in Bury New-road, or Great Ducie-street, Manchester. A plan of the site and particulars may be obtained on application to Frederick C. Hulton, Clerk to the Manchester Assize Courts Committee, Salford, to whom the designs must be sent by the 1st March next.

The Havelock Testimonial.—The Havelock Testimonial Committee have decided upon giving to Mr. Behnes, sculptor, of Osnaburgh-street, Regent's-park, the carrying out of the Havelock statue at Trafalgar-square. Mr. Behnes's No. 4 model has been selected as the most suitable, both as regards attitude and likeness. The statue will be erected on the vacant site adjoining the Nelson column.

The American Steam Ram and Battery.—Stevens' Steam Battery is an iron vessel, now building for harbour defence only, under a contract with the late Robert L. Stevens. It is about 440 feet in length and 50 in breadth, and is built apparently for speed, being very sharp forward, with clean run, greatest breadth abaft the centre of length, and with flat floor. She is now built up only to about the light-load line, the "planking" being ½-inch boiler-plate double riveted to U-shaped angle-iron "timbers" about 20 inches apart; no "ceilings" as yet; "deck-beams" of U-shaped angle-iron are in for two rather low decks, and the hold has on each side a large iron tank, extending some 200 feet amidships, and leaving but about 20 feet of space between the two tanks on the line of the keel. Each tank appears to be independent of the other, and at the forward end has an inclined engine, very heavily proportioned, which seems to be arranged for condensing air into the tank. Over the top of the tanks are large pipes or boiler-plates, connecting the engine with the tank at several places, as if the tank were composed of subdivisions. No propelling apparatus is yet apparent. The plan, as report says, is to carry a heavy battery, of long range, as near to the water as possible, using the air tanks to secure safety from sinking if pierced by a shot below water, or from water which would wash into the low ports. The battery is to be covered by a sloping roof so that shot would glance off, and the vessel to have speed enough to be able to keep at long range. The original appropriation by Congress was 500,000 dollars "toward" the construction. The executors have claimed that a little over 800,000 dollars has been expended, and that about as much more will be required to complete the vessel, though whether this is to include equipment and armament is not definitely stated. There has been much doubt expressed if the thing will ever be completed, although Mr. Stevens did contract for a specific sum, and of which he had received on account the appropriation of half-a-million dollars, as above. At present there is only enough work doing to justify the expression that "the work is progressing."

Notre Dame.—The restorers of Notre Dame de Paris are now taking in hand the interior of the choir, and have already swept away the cumbrous marble arches, false in style and heterogeneous in material, which have so long defaced it. They are about, too, to complete the cathedral according to its original plan, by raising a pierced Gothic spire in the centre of the building.

Digitized by Google

THE PROPOSED STEPHENSON MONUMENT AT NEWCASTLE.

That the question, as to the best kind of public memorial to be raised as a tribute to the illustrious dead, ought in a great measure to be guided by circumstances, every one will admit; and it will on the other hand be granted that, in spite of the utmost preliminary care and deliberation, but very few, indeed scarcely any, even under the most favourable auspices, have realised the ideas of their projectors. Then again, to show the diversity of opinions which may exist upon the very same subject, we have only to point to the amusing contrasts which were afforded by the examination of the designs for the Wellington Monument to be placed in St. Paul's Cathedral, or even the multiplicity of schemes which have been actually carried out in commemoration of our deceased Crimean heroes. From the range of the contents of Westminster Abbey and St. Paul's down to the latest additions to Trafalgar-square, all partake of the same unsatisfactory heterogeneous character. What wonder is it therefore that the good people of Newcastle cannot agree as to what kind of monument they shall rear in memory of their late distinguished county-man George Stephenson. Yet in their case there is this advantage, that nothing is yet, we understand, really decided on, and therefore there is the greater hope that the discussion which is now afloat will have a beneficial tendency. It is a matter for congratulation to observe with what enthusiasm and energy the proposal to erect the Newcastle memorial has been met by those classes who, either appreciating the genius of Stephenson, or profiting by his industry, have taken the initiative in the promotion of this praiseworthy object. As Lord Ravensworth has remarked, "In this, the capital town of his native county, some enduring monument should be placed of a description which shall leave no doubt upon the minds of every passer-by that it is to the memory of George Stephenson."

In the present state of affairs the possibility (based on a resolution unexpectedly proposed and confirmed at what had been given forth as to be merely a preliminary meeting) is, that the whole will be confided to "some sculptor of eminence."

To such a decision there are many malcontents, and reasonably too, when the site it is remembered is to be an out-door one, and, if the most appropriate and eligible one be selected, is in the centre of a large open space—the locality suited above all others for some architectural attraction as a focus, and in which an insignificant bit of sculpture would be worse than useless. A life-size figure—perhaps sitting—placed on the spot referred to, within the area of the triangle formed by the junction of Neville-street with Westgate-street, on a pedestal equal to the height of the figure, would appear a mere pigmy in the locality of the Railway Station, the Literary and Philosophical Institution, the Surgeon's Hall, the Assembly Rooms, and St. John's and St. Nicholas' Churches, and would bear no more proportion to the area of that admirable site than it would to the wishes and expectations of the inhabitants. To obviate this objection however it may be urged that the monument might be colossal; to which we reply, that to be at all equal to the necessities of the case, it must be giant-like in its proportions, and this would inevitably destroy its *individuality* of purpose; besides it is by no means conceded that statues exposed to the rigours of the seasons are adapted to any climate, much less to one so capricious as ours.

In connection with this specific subject of Stephenson's monument a very able address* has been prepared by an architect resident in the vicinity, who naturally feels warmly interested in the issue of the contest. To this we are indebted for some of the foregoing remarks; and the following may be quoted as exemplifying the author's views on the comparative claims of architectonical and sculptural memorials generally.

"Monuments may be generically grouped into the architectural, sculptural, and architectural and sculptural combined. The sculptural monument is usually life-size or colossal, in stone, marble, bronze, or other metal; and, until more modern times, was rarely separated from its architectural parent. There are instances—as the Colossus of Rhodes—where statues were erected isolated and distinct from all buildings; but so far from these being examples of sound sense and true taste, the fact that they were more the product of boastful ambition than of pure sentiment, is a sufficient reason to deprive them of the reverence we are naturally disposed to give to precedent, especially when that precedent was contemporaneous with a high state of cultivation." .....And without entering into the nice distinctions of colour, some consideration is due to the effect produced upon the mind by beholding an exposed marble statue, bleached on one side and blackened on the other—results which atmospheric influences in Newcastle produce long before the figure has time to grow hoary with age—or of a deep brown bronze, without sun shadows, and bearing a strong resemblance to the natural complexion of a foreign and degraded race called by our transatlantic friends 'men of colour.'

* * * *

"Monuments of the architectural class, comprising pyramids, monoliths, tombs, or obelisks, constitute examples as foreign to the present object as those of the purely sculptural class. But from the earliest ages, rude hieroglyphic carvings, which afterwards developed into chaste sculptures, may be found in almost every example. The columns, triumphal arches, and choragic monuments of ancient Greece and Rome, were architectural structures sculptured by way of adornment. Architecture is, therefore, rather the parent of the art of sculpture than the elder sister; and never has sculpture been placed in position apart from architecture without suffering by the innovation. In London, the statue of the Duke of Wellington on horseback, for want of an architectural pedestal and covering, has been placed upon a triple arch, to the degradation of our national taste and the regret of every artist. In Liverpool and Manchester, the colossal figures of their local celebrities, and the statues of Wellington and Peel, are far from satisfactory, considering their cost, although, in these cases, the nature of the sites have doubtless had much to do with the character of the monuments; and, to the general public, they appear to serve no higher purpose than the Sebastopol guns at Sunderland or Stockton do. They are mere objects of wonder. Monuments of the combined architectural and sculptural class, including columns, triumphal arches, shrines, and tombs, constitute the best examples. Monumental columns, with colossal figures on the top, are in equal bad taste with merely sculptural monuments, and for the same reasons, with this additional reason—viz., that the figures are placed beyond the proper limits of sight. You know they are there, but that is all.....Those of the arch class are suitable only for conquerors, and the sculptured statues and bronzes record the history of their triumphs, and, as aids to history, are doubtless useful enough in their way. But this is not the form we want in Newcastle for George Stephenson. He, too, was a conqueror, but his conquests were peaceful. The results of the victories which he achieved have been beneficent, as the victories themselves were bloodless. The influence of his exertions and career is felt throughout the civilized world. Nations are learning their dependence upon each other, and the facilities for rapid communication are constantly becoming more numerous. The domain of commerce has been widely extended; and a new and nobler chivalry is succeeding the chivalry of war. The impulse which has been given to agriculture has resulted in its elevation to a science. The labour of the artizan has been lightened, and his comforts increased. Effective means for preserving life amidst the danger incident to the working of our coal fields are in general operation. With all these departments of human interest the name of George Stephenson will be for ever identified, and the impetus which has thus been given to the progress of society must continue to be felt to the remotest ages of the future. It is for the public taste to decide in what style the monument shall be, whether of Greek, Roman, mediæval, or modern character. Unquestionably, the finest specimens of modern monuments are Sir Walter Scott's at Edinburgh, and the Martyrs' Memorial at Oxford—the latter of pure mediæval character, the former of more original conception, though based on mediæval example."

* * * * *

"If a suitable monument to George Stephenson *could* be described, it would be described as an architectural canopy—nearer than the heavens—within which, on a sculptured pedestal dated by his inventions, artistically and perhaps somewhat emblematically arranged, would stand the man himself as he appeared in the midst of us. His whole form should be faithfully exhibited. His physiognomical expression should be represented with photographic fidelity in the marble; and even his peculiarities of dress and posture should also be accurately

* 'The Stephenson Monument: What should it be?' By Thomas Oliver, architect. Newcastle-upon-Tyne. 1858.

Digitized by Google

delineated. He should not be too young to appear a prodigy of success, nor too old to indicate natural decay. His attitude should be that in which his physical constitution rested, and his features should reveal his clear and manly intellect. Above him should be *our* work, erected by our labour and cost; around him emblems of his own work, and of his extraordinary success; while, symbolising the healthful influences of his example and career, streams of crystal water should issue in a perennial flow from granite fountains for the welcome benefit of all!"

WORKS AT EXETER COLLEGE, OXFORD.

Among the most important and extensive architectural works of the day are those now rapidly approaching completion at Exeter College, Oxford, under the superintendence of Mr. George Gilbert Scott. The great popularity of this college had rendered a great increase of accommodation necessary, and the old chapel had long been crammed with seats, arranged in no very decorous manner, and yet quite inadequate to the requirement of the members of the College, when it was determined about three years ago to build a new chapel and remodel the entire College.

The site, a very noble one, lying between Brasenose-lane and the Broad-street, and bounded on the west by the Turl, was chiefly occupied by two quadrangles—a large one, now commonly called the Old Quad, nearly square, the western side of which extended the whole length of the site in the Turl, and contained the tower gateway; and a smaller quadrangle called St. Helen's, from an ancient church and cemetery which formerly stood there. This quadrangle was separated from the Fellows' Garden by the library. Northward, towards the Broad-street, there was a great confusion of building, &c., consisting of additions to the rector's lodgings, in no particular style of architecture; the "Rector's Garden," an unwholesome little enclosure, carefully guarded by iron railings; the Old Buildings, less commonly known as the Prideaux-buildings, and built originally for the accomodation of foreign students; a fragment of the old city wall with an arch pierced through it; the "New Buildings," ashlar in the street and Gothic, but of brick and no style behind; a variety of offices, another little garden, and a fine row of poplars, the loss of which all old Exeter men regret to this day. The chapel and the rector's lodgings stood on the north, and the hall (a very fine specimen of the revived Gothic of the time of James I.) stands on the south of the old quadrangle.

Of these buildings nothing now remains but the east, south, and west sides of the Old Quad, and the original "New Buildings." All the rest have been swept away. The present arrangement is as follows:—On the site of the old chapel and the rector's lodgings rises the new chapel; the old library has been rebuilt on an improved plan; the St. Helen's Quadrangle has been enlarged by throwing back its north side, and on the site of the miscellaneous buildings and little gardens an entirely new quadrangle has been built, with a tower gateway opening into the Broad-street. The offices have been compressed into a much smaller area, and are entirely concealed behind the east side. The rector's new lodgings are in the south-east angle, and are extended eastward so as to form the north side of the St. Helen's Quadrangle. Lastly, it is intended to re-erect a portion of the old Prideaux-buildings in the gap between the Turl front and the house of Mr. Parker, the publisher; so that old Exonians will not be wholly deprived of the curious wooden oriels the memory of which must be so familiar to them. The arrangement of the site is certainly the best possible, and reflects the highest credit on the skill and judgment of the distinguished architect. The new works are:

1. *The New Quadrangle.*—The alterations were commenced and will for the present end with this. The first step was the destruction of the poplars and the erection of the Broad-street front, which has a very handsome *façade*, but is somewhat marred in its effect by an attempt to make it harmonise with some adjoining buildings which were erected many years ago in inferior Perpendicular. It is not possible to clothe the forms of one style with the details of another, without risk of failure. It would have been better therefore to continue the previous new buildings in Perpendicular of a superior quality. But we believe Mr. Scott is not responsible for the employment of Perpendicularised Decorated. At all events much credit is due to him for the manner in which he has overcome the difficulty; the work in less skilful hands would have proved a failure. The remainder of the quadrangle is of very pleasing character, and is not brought into contrast with the older buildings; the windows, especially those in the west side (now nearly finished) are very gracefully moulded. Within the rooms and stone staircases are admirably arranged and well lighted, and stained glass of a simple description has been introduced with good effect into the windows of the latter. The chapel bounds this quadrangle on the south.

2. *The Rector's Lodging* stands immediately to the east of the chapel. It is a very commodious house, well arranged internally, and highly ornamental to the College. The hall is 30 feet in length, and the dining-room and drawing-room are each about as long. The entrance doorway is a singularly beautiful composition, richly carved and moulded, and with shafts in the jambs. The portion in St. Helen's Quadrangle is very highly decorated, the drawing-room windows having tracery, and very pretty balconies with railings of wrought iron-work arranged in quatrefoiled circles.

3. *The Library.*—The old library was a poor building of a Classical style, and very inconveniently arranged, with clumsy galleries and cumbrous stairs within. The building which Mr. Scott has substituted stands upon the same site, and is acknowledged to be one of the most effective edifices of the kind in Oxford. It is divided by a floor into two rooms, the fittings of which are throughout not only very richly carved but most conveniently arranged. The upper room, which is lighted from above by stone dormers very skilfully treated, is reached by a newel staircase contained in an octagonal turret with a pyramidal capping. It has a fine roof of stained deal, and is of excellent proportions. A wing communicating with the main building on the north is partly used as an Undergraduates' Library. The walls are faced internally with ashlar instead of plaster, an architectural luxury rarely attainable in these days. There is a great deal of carving on the exterior, but no appearance of overcrowding. (A plate of the New Library was given in this *Journal* for August 1858, to which we beg to refer our readers.)

4. *The Chapel*, which extends the entire length of the north side of the great quadrangle, is worthy of a more particular description. Not only is it undoubtedly the finest ecclesiastical edifice in the University, but it is the *chef-d'œuvre* of its accomplished architect. The great roof of noble pitch towers high above the surrounding buildings, and forms a conspicuous object in the distant views of the city; while the tall and graceful *flèche* which surmounts it adds to the number of the towers and spires of Oxford, and is by no means unworthy of its place in that unrivalled group. The plan of the chapel is rectangular, the east end being extended into a pentagonal apse. Its interior dimensions are as follows:—Length 91 feet, width 30 feet, the height from the ground line to the ridge of the roof is 84 feet, to the summit of the vane 150 feet. The area is subdivided into an ante-chapel (the westernmost bay) 20 feet long; the chapel proper 56 feet, and the apsidal sacrarium 15 feet long. It is divided into five bays, including the ante-chapel, which are separated by buttresses of great projection, and well able to support the massive stone vaulting of the roof within. These buttresses are plain beneath, but are richly decorated above with crockets and finials (the carving of which is still in progress), and on each is a niche, intended to be filled with statues gradually as funds shall be provided for the purpose. There is a three-light window, with varied geometrical tracery, in each bay; the windows of the apse are of two lights, and three of the five are to be filled with stained glass of the richest description, which is now being prepared by the well known artists, Messrs. Clayton and Bell, who are old pupils of Mr. Scott. At the west end are a wheel window richly carved and one of two lights in the space between the roofs above. A constructional organ gallery has been built in the lower part of the west wall, which to our mind is the least successful part of the design, as it has an appearance of weakness; but the difficulties of cramming so much into so small a space were very great. Mr. Scott has overcome them as far as was possible. This gallery and the main roof of the building are approached by a newel staircase in an octagonal turret, which adds greatly to the external effect of the chapel, though every one must regret that the small spire with which Mr. Scott intended to have crowned it has been omitted for reasons of economy. The present square outline does not harmonise well with the other outlines of the chapel. The entrance doorway, with a rich pedimental head and tympanum prepared for carving, is on the south side of the ante-chapel. There are niches in the jambs which are to be filled

Digitized by Google

at once with statuary. The interior proportions of the chapel are very noble and striking by reason of the unusual height and the great richness and variety of the mouldings in every part. This will be greatly enhanced on the completion of the works by the proposed large use of shafts of polished marble in the jambs of the windows and as supports to the main ribs of the groining. Devon and Cornwall marbles alone will be employed, and indeed nothing can be more beautiful than the Lizard serpentines of the latter county; but it is proposed in this way to recognise the fact that this College was originally founded by Walter de Stapledon, Bishop of Exeter, for natives of his diocese, which consists of these two counties. A great deal of marble will also be employed in the arcades and reredos beneath the sills of the windows in the apse. The chapel will be divided from the ante-chapel by a stone screen of elaborate and costly workmanship, the munificent gift of the present set of undergraduates. But the main feature of interest in this chapel is the groined roof of stone, the span of which it will be remembered, from the dimensions already given, is no less than 30 feet. Vaulted roofs are rare indeed in modern times, on account of the great expense, and even risk, attending their construction. The few that have been built may be counted up on the fingers. Mr. Scott may well be proud of the Exeter roof, it is worthy of the men who vaulted over the glorious cathedral of the founder, Stapledon, in the fourteenth century. The filling in of the spaces between the ribs has been judiciously varied by the introduction of narrow stripes of a dark yellow stone, quarried at Guyting in Warwickshire, which affords a pleasing contrast to the somewhat monotonous tone of the Bath stone, of which the chapel is built, and will preserve the balance of colour above with that imparted to the walls by the marble shafts below. Externally the roof is covered with Stonesfield slates. The *flèche* is of wood, and will be covered entirely with lead.

Mr. Symm, of Oxford, is the contractor for all the works at Exeter College; and Mr. Buckeridge, architect, an old pupil of Mr. Scott, resident in Oxford, has superintended their execution from the beginning. Both are deserving of the highest praise for the manner in which they have carried out the intentions of the architect.

ON THE APPLICATION OF NATURAL FOLIAGE TO ARCHITECTURE.

By James K. Colling.*

(*Concluded from page* 8.)

After giving many instances of the judicious alterations which might be made in various leaves and flowers, the author said,—

I would particularly wish to point out that there are certain natural principles and forms running through both leaves and flowers, that they follow a regular geometrical distribution of parts, and that the form of leaf or flower follows naturally from the principle—or, if I may so say, from the anatomy upon which it is set out. Thus flowers radiate in threes, as the lily,—leaves grow in threes from the same point in the stem, and are in perfect harmony with the flower, as the anemone,—leaves divide in threes, as in the water avens, clover, and wood sorrel,—doubly triple, as in the columbine,—and further carried on to the greatest intricacy, as we see in the parsley. Flowers again are cruciform, as in the wallflower,—leaves also grow with the same arrangement, as we see in the lilac and the maple. It should be noticed too that that arrangement of the leaves in pairs (called "opposite leaved") extends through the whole anatomy of the plant or tree,—the leaf-buds being formed at the base of the leaves, they also are in pairs; the leaf-buds become branches, all of which are arranged to grow in an opposite manner, the same as the leaves. But there are many accidental circumstances (such as the leaf-bud being destroyed by insects) which in the case of branches prevent the opposite principle from being too strictly carried out, which, if it were, would give the tree too stiff and formal an appearance. So also in alternate leaved plants or trees, it follows through the whole system, and all the branches are alternate. But to continue from what I have called the cruciform arrangement.

We next come to flowers which are divided into five petals, or set out on the pentagonal principle, and this division is again seen in the leaves—they are first divided into five lobes, with a semi-radiation, simply cut out as in the ivy, divided with deep eyes as in the vine, which we again see in the flower of the hollyhock. The lobes again subdivided as in the maple and bryony, —or separated into distinct leaflets as in the Virginian creeper,— and running again into intricacy in the field geranium and other plants. Then we have the seven lobes in the hollyhock,—seven leaflets in the horse-chesnut,—eight petals in the coreopsis,—ten divisions as in the campanula and stellaria,—until we arrive at multiplicity in radiation, as we see in the daisy and sunflower, and in the leaf of the lupin. Further, we see leaves and flowers take leave of radiation altogether. Flowers run into a vast variety of forms (far too numerous for me to attempt to go into), such as the pea and bean tribe, and many others. Leaves branch in pairs from a central leaf stalk, as in the elder and rose leaf, which is carried further in the acacia and ash, and is again subdivided and carried into the greatest intricacy in the ferns. In the leaflets of the acacia we see also the heart-shape form which we observed in the petals of the strawberry and the primrose, —also again in the violet leaf, but formed the contrary way.

All these facts show that there are certain natural laws, by studying which the artist can produce what form of leaf or flower may best suit his purpose, upon perfectly natural principles, but without following any one leaf or flower in particular—thus giving him such a vast field to work in that there need be no limit to genius or invention.

There are also a vast variety of other forms and objects in nature, beyond those to which I have more particularly drawn your attention, which will present both agreeable and valuable means of study. The observing too of plants and flowers is at the same time one of the most agreeable and pleasant of occupations; in the words of Lord Bacon—"It is indeed the purest of human pleasures, it is the greatest refreshment to the spirit of man," for "God Almighty first planted a garden." Things are never too commonplace in nature for study and observation—

> "There's beauty all around our plants, if but our watchful eyes
> Can trace it 'midst familiar things, and through their lowly guise."

Elegant and graceful form may often be suggested by the meanest weed. What, for instance, can be more beautiful than the clasping of the leaf in the common sow thistle—with the ears of the leaf turned into a spiral form on each side of the stalk. The dandelion has a most peculiar formed leaf, which presents a good study of light and shade. There are also many other leaves particularly valuable for the disposition of the light and shade upon them. Heaths again present some elegant combinations and clusters of bell-like flowers. In other flowers we get suggestions of colour in the foliage or varieties in the form of their flowers; and in sea-weed, another field for study, what beauty and elegance we see obtained simply by branching and forking. One especially, the *fucus serratus*, appears to me to offer a valuable hint for the carver.

Thus we may go on, and let us but follow up this search into the anatomy of vegetation, and it will give us scope and power for invention. If we design fresh foliage, let it obey the laws of nature, and it will not fail of being beautiful. But what is the fact?—how often do we see in modern foliage the very first and simplest law of nature totally disregarded, and foliage made to grow two ways—growing out at both ends at once! What can be more absurd? Yet it is done every day, more particularly in Classic foliage. And as to any natural form or divisions in the leaves, it is never thought of; we are content to go on copying the leaves of the Greeks and the Romans, without ever thinking it worth while to make them at once more natural, or even to get any more variety in form. We look upon it as architectural foliage,—we are willing to accept the conventional forms as being the highest and most beautiful that can be attained; and we completely and purposely separate it, and cut it off from the original source from which those old artists took their ideas. We shut out nature, and go on every day further and further from her. Modern foliated carving should be based upon nature, and nature's laws, as all carving, whatever may be its style, has been originally; but we may and should take ideas from all styles of architecture, but let us not confine ourselves or copy from any. Copy nature in the vast variety she gives us and never-ending beauty of form; and let us have a little of this variety in our architectural enrichments. Its leading characteristics should be elegance of form and beauty of light and shade, whilst retaining all the quietness and repose necessary for its various positions as architectural enrichment.

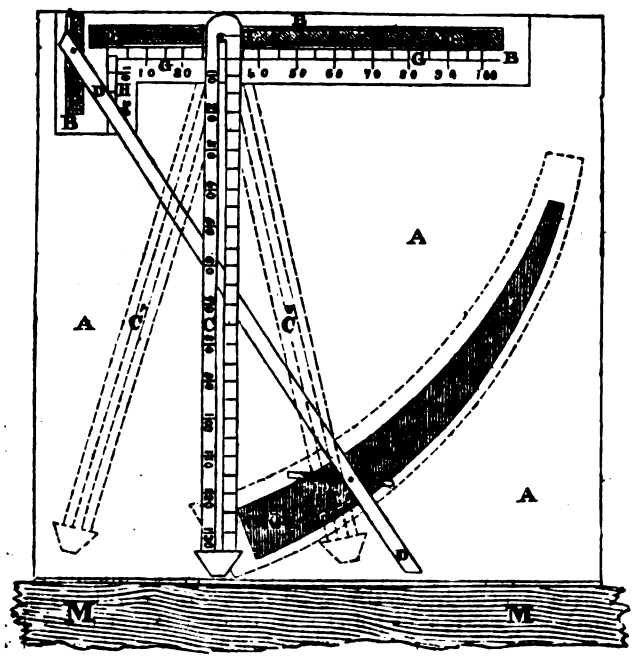
* Paper read at the Liverpool Architectural Society.

Digitized by Google

THE KREMNOMETER.

THE name of the instrument, a drawing of which is annexed, is derived from two Greek words, whose combined meaning signifies to *measure slopes*. The purpose which the Kremnometer is intended to subserve is, the setting out the widths of cuttings and embankments on a sloping cross-section, and it may be described as follows:

A A A, the stock or frame of the instrument, consists of a piece of mahogany or other hard wood 9 inches square and 1¼ inch thick. B B B, is a thin plate of German silver, sunk flush with



the polished surface of the frame. C, is a plummet of the same metal ⅜ of an inch broad and $\frac{1}{40}$ of an inch in thickness, having a projecting piece of metal at the end to insure its hanging vertically. There is a slit in the centre of the plummet from end to end, and it is graduated into feet along its whole length, (the drawing shows only every fifth foot) 16 feet to an inch is a convenient scale, and sufficiently large for practice. D D, is the slope bar of the instrument, ¼ of an inch wide and $\frac{1}{50}$ of an inch thick. E E, is a groove cut in the frame, in which the pivot-block L—on which the plummet is suspended—moves up and down. F F, is also a groove at right angles to the other, in which the centre of the slope-bar moves. G G and H, are scales of the same graduation as that on the plummet. The scale G G must be perfectly parallel to the sole-plate of the instrument; and the scale H exactly at right angles to the same. K K, is a slit cut in the frame with a shoulder on each side, which, with the cross-bar shown in the engraving, serves by a clamp-screw to keep the slope-bar at any slope to which it is set. M M, is a straight-edge of wood, from 10 to 20 feet long, 6 inches broad, and ½ an inch thick. It is not attached to the instrument, but serves for placing it in proper relation to the slope of the ground.

The method of applying the instrument may be briefly described. First, fix the slope-bar at the required slope of the work to be set out; this is done by having a mark at the bottom of the instrument, perpendicularly under any point, say 30 on tha scale G G. Lay the plummet over this line; then place the slope-bar at the half-width of the formation level of the cutting or embankment, shown on the scale H. This half-width, added to the ratio of the slope to the base, will show the half-width of a horizontal cutting on the plummet scale at any depth of cutting to which the plummet is set. If, as in the engraving, the half-width of the formation level be 15 feet, and the slope 1½ to 1, then a cutting of 30 feet deep of a horizontal cross-section gives a half-width of 60 feet. The scale H, which represents the formation, is counted from a point the same distance from the edge of the groove E E, as the centre point on which the plummet swings. When the slope-bar is adjusted it is fixed by the clamp-screws behind the slits K K and F F. Unscrew now the clamp which holds the sliding block L, and place the plummet on the scale G G, at the depth of the cutting or embankment where the slopes are to be set out, and there screw it tight; then place the straight edge M M along the slope of the ground and set the instrument upon it. According to the amount of slope the plummet will hang, for example, at C, and the reading on the scale where it cuts the slope-bar is the width for one side measured—not horizontally but along the straight edge or slope of the ground. Now turn the instrument half-round, and the plummet will hang as at C″, and the reading on the plummet scale where it cuts the slope-bar, as seen through the slit in the plummet, will be the width for the other side. Proceed to the next point; and again setting the plummet to the depth shown in the section, lay out the widths as before.

It would occupy too much space to enter into an investigation of the principle on which the instrument is constructed. It may simply be mentioned that whatever arc of a circle the straight-edge or slope deviates from the horizontal, the plummet describes the same arc.

Those who are acquainted with the ordinary methods of setting out widths on sloping ground with the level need not be told how tedious the process is; and although the instrument described will not supersede the level in all cases, yet where the slope is regular or nearly so, which it generally is, the Kremnometer will enable at least twenty times more work to be done than could be done by the level alone.

Sir John Macneil's instrument for the same purpose, a drawing and description of which are given at the end of his Tables of Earthwork, requires that the angle of the slope be found for it by a separate instrument,—a process nearly as tedious as that of setting out the widths at once with the level.

The Kremnometer is the invention of Mr. A. S. Wilson, C.E., Aberdeen, and is manufactured by Messrs. Smith and Ramage, of that city.

DURHAM CATHEDRAL.

IT has been decided to restore the whole of the upper stage of the great central tower of this cathedral, and to replace the present parapet by one somewhat different in design, and more raised above the cornice. The four angles appear to have been intended to carry each a large pinnacle, but it is uncertain whether they ever did so; there are no prints extant which show anything of the kind, nor is it now intended to carry out this feature, inasmuch as pinnacles would at least interfere with, if not destroy, the simple grandeur of the tower as it now exists. Although the squinches and corbelling will of course remain within the belfry stage, externally no indications will be evident beyond building up a solid pier to the height of the new parapet, and capping it just above with a plain cope moulding. The new parapet will, like the old, be perforated. The lower parapet to an open gallery which runs round the outside of the tower at the foot of the belfry windows will be entirely new, and of more appropriate design than the present one, and it is intended thoroughly to restore the whole of the eight windows, and to substitute the best stone for the cement, with which the general facing of the walls and many of the architectural features have been repaired. From the great height of the tower these contemplated works will involve considerable practical difficulties, and be attended with a proportionate expense, roughly estimated at between 5000*l.* and 6000*l.*

THE ARCHITECTURAL EXHIBITION.

THE near approach of the period fixed for the re-opening of the Architectural Exhibition in its new, and let us hope permanent, quarters, appears to be stimulating the committee to renewed exertions in obtaining from the profession that important co-operation which will enable them to inaugurate the coming season with a goodly array of choice drawings. We earnestly hope that their appeal will be successful, and that the efforts which have been made, and so praiseworthily too, by a few thoroughly zealous individuals, will be cordially seconded out of doors. It is with no small satisfaction that we learn the pecuniary results of their last year's labours; for, despite of the unforeseen delay in opening (caused by the alterations in their *then* gallery being incomplete), the balance sheet for the season

Digitized by Google

is reported to exhibit, not merely a cancelling of outstanding liabilities, but a surplus in the honorary treasurer's hands of about 40*l*. This is indeed encouraging!

A recent inspection of the new galleries in Conduit-street, warrants the expectation that they will prove in every way suited to their purpose; for though the walls were mostly in a rough state, and very little appearance of finishing was anywhere discernible, it was not difficult to perceive that the proportions of area and wall space, and the all-important item of lighting promise well. The latter is derived wholly from above, by means of skylights—in a handsomely ornamented ceiling of curved form—which extend the whole length of each room, and which are filled with large sheets of deadened glass, imparting a subdued yet sufficiently cheerful tone. Concerning the other architectural decorations, &c. we must reserve our remarks till all are completed, but we may state that, externally, all has been done that was contemplated, virtually little more than a thorough renovation of the old building, which, being of the good old-fashioned school, and, moreover, the well-appointed residence of successive persons of distinction, possessed in itself several features of architectural though unobtrusive character.

SUGGESTIONS FOR THE IMPROVEMENT OF LONDON, AND FOR NEW PURIFYING SEWERS FOR THE THAMES.

An ingenious French architect, M. Horeau, who has now for some time been resident amongst us, has during the past month been submitting to the examination of members of the profession and others invited for the purpose, at the Hanover-square Rooms, a great variety of schemes devised to ameliorate the condition of our great city. Of these propositions generally it is enough to state that they evince an immense deal of study and patient application, so far as planning goes, with some amount of talent in the design of the different groupings (albeit the fanciful, and we should fear the unstable, engross a larger share); but that the magnitude of the schemes, and the enormous outlay that would be requisite in carrying them out, would alone present, we should say, insuperable obstacles to their accomplishment. Some of these ideas it may be remembered were embodied in the author's designs for the new Government Offices; these were now re-exhibited among the rest of the drawings, with an ingeniously written explanation. We observed also M. Horeau's designs submitted for the universal Exhibition of 1851, and a plan, sections, and elevation of that proposed for the Paris Exhibition. In all there were thirty-six drawings, all bearing the stamp of originality, while many possessed greater recommendations.

One subject to which the author seems to have paid much attention is the sewerage of London, and he has conceived a project for the construction of new purifying sewers for the Thames, which in these days of sanitary improvements it may not be amiss briefly to describe, without pronouncing any opinion on its merits.

Among the objects proposed to be attained are, to avoid the difficulties of levels; to avoid expensive engineering; to avoid the formation of an offensive deposit as well as the reflowing of sewage towards the metropolis. The intended sewers would consist of a vault of sufficient capacity to enclose four iron gutters or "rivulets" (two large and two small) supported by iron bearings independent of the construction of the vault; these rivulets to be constructed at different heights in order to facilitate their junction with the present sewers (which are at different levels) and to have a slight fall; they would also be divided into as many basins as would be required by fixed sluices, open only at their summits for the purpose of receiving deposits; this would not arrest the ordinary current. Moveable pipes or gutters would be provided to carry into the adjoining rivulets the first matters which are not to be received in deposit, either to remove the manure or to allow of repairs. The purified water which could be obtained in a short time at the summit of the deposits might be conducted into the Thames, especially should this water be made to pass into channels containing purifying agents. Underneath the purified water would naturally be found the liquid manure, and after this is drawn off there would remain at the bottom the deposit of solid manure; this should be covered with lime or alum to preserve its quality and facilitate its being put into casks, the casks, being raised by pulleys, could be placed on one of the three railways (with moveable floor) placed above each other between the rivulets. The railways might be made serviceable in various other ways. Six galleries (three on each side of the vault) would be appropriated to the inspection of the junctions of the old sewers, to the proper disposal of the raw matters to separate into the various rivulets, for fixing and repairing the numerous water and gas pipes, &c. &c. Moveable scaffolding, ladders, syphons, pumps, cranes, and the like, could be made available inside in different ways, thus avoiding to a great extent the obstructions along the public way which the present system usually entails. The sewers would be lighted by jets of gas, which could be further assisted by daylight, by reflectors, or by the apertures occasionally necessary above.

ON THE APPLICATION OF CHARCOAL TO THE VENTILATION OF SEWERS.

The subject of the ventilation of sewers has from its importance been constantly ably discussed by both theoretical and practical men as well as members of the engineering and medical profession for many years past, but does not appear even yet to have reached a satisfactory settlement. In a valuable report recently made to the Commissioners of Sewers by their engineer, Mr. Haywood, "on the application of charcoal to the ventilation of sewers," that gentlemen quotes the suggestion to the commissioners by their medical officer, Dr. Letheby, of the application of charcoal to ventilation, as follows,—

"Now in making a practical application of these facts, it is manifest that we have in common wood charcoal a powerful means of destroying the foul gases of sewers. How it is to be applied is fortunately a question of but little embarrassment; for let the sewers be ventilated as they may—either by open gratings in the street, or by the rain-water pipes of the houses, or by the pillars of the gas lamps, or by tubes carried up at the landlord's expense from the drains of every house, or by especial shafts in the public streets,—in fact, let the gases go out of the sewers how they will and where they will, you have but to place a small box containing a few pennyworths of charcoal in the course of the draught, and the purification of the air will be complete. As far as we know, the strength and the endurance of this power is almost unlimited, so that when once the air-filter has been set up it will last continuously for years. Its action also upon the draught is not particularly injurious; and I have no doubt that the temperature of the sewers, and the agencies which are now at work in circulating the air and ventilating them, will be sufficient to keep up a current of foul air through the filters; and if these were multiplied to a large extent, the friction of the gases upon the charcoal would be reduced to an insignificant amount."

Mr. Haywood proceeds to remark,—

"The system suggested is in fact to place a sieve or strainer of charcoal across every ventilator and gully to the sewers, through which the air shall be filtered and deodorised as it escapes. The effectual application of these sieves will, I apprehend, neither be so easy nor so cheap as may be anticipated.

I have shown in my report that the number of openings to the sewers within the city is 47,819: these openings are from ventilators, gullies, sinks, waste-pipes, water-closets, and rain-water pipes; through the whole of which at times, it is perhaps not too much to say, effluvium escapes into the atmosphere, and any system only half does its work which does not deal with the whole of them. There are 2810 gullies and 1065 ventilators in the public way; it is owing to the escape of effluvium from these that the public experience the greatest annoyance, and from the latter especially, because from their area it escapes in larger quantities at one spot. Whether these 3875 are worse in their effect upon the public health than the other 43,944 openings I offer no opinion.

The application of charcoal to the existing street ventilating gratings may be made in two ways:—

Firstly,—by reconstructing the ventilators at the heads in such manner that the air must pass through the charcoal sieves before escaping, the gratings remaining placed as now at the street level. A simple mode of reconstructing them for this purpose has already been suggested by the surveyor to the Hammersmith Board of Works (Mr. Bean), who, with the medical officer (Mr. Burge), some time since commenced experimenting upon the

Digitized by Google

prevention of the issue of effluvium from the street ventilators by means analogous to that suggested by your medical officer.

Secondly,—by removing entirely the present ventilating gratings, and connecting the shafts with pipes to go up the fronts of the houses to a convenient height, where they may terminate in chambers having charcoal sieves and escape outlets above; it would be a waste of money to carry these far above the street level, for unless the action of the charcoal is uncertain no nuisance can possibly accrue.

Of the two the first will be the cheapest in adaptation,—the second the readiest for the purpose of inspection, and I think, upon the whole, the best.

Dr. Letheby considers these charcoal sieves will not be particularly injurious to the currents which now circulate in the sewers and aid in ventilating and purifying them, and enable workmen to continue in them. Future experience must determine this; but I am of a contrary opinion, and think it more probable that three or four ventilators will be required where there now is but one, unless the sewers are relieved more freely by the house drains and untrapped inlets than at present.

To the increase of the number, should my opinion prove correct, there will be no practical difficulty; it will only be a matter of expense, but it will be found in all cases cheaper and more convenient to bring the additional ventilating tubes up in front of the houses than to terminate them at the street level.

But a better mode will be to adapt the lamp columns to the purpose, as not only would all question of the right of placing the tubes up in front of the houses be avoided, but the charcoal sieves might be made more accessible and less obtrusive, and the heat of the gas when burning would aid the functions of the shafts as eduction tubes, and, as these gas columns are about 750 in number, they will supply situations for that additional number of ventilators. To effect this the whole of the gas columns must be re-modelled, or rather gas columns of an entirely fresh design must be cast.

But, assuming that charcoal has all the virtues ascribed to it, it follows that stench of any sort need be no longer feared, as its destruction, when the charcoal is properly applied, is certain; and very large openings to the sewers might be made at convenient situations, many of which at once suggest themselves to me,—as near to the public urinals, and at the existing side entrances, and by special shafts erected at the intersection of streets, and by cab-stands, &c., so that all fears of preventing the circulation of air in the sewers may be allayed, and it will only become a question of how many openings will be needed, and their cost.

With regard to the gullies I see no means at present of applying it in such manner as that it shall be easily accessible, and not either impede their action or become impeded in its own purifying action, so that the gullies must remin as they are, and whatever harm they now cause to the public health will continue nevertheless. Nor can I suggest any convenient means of applying it to the thousands of inlets to private houses; something might be done by those inhabitants who would be content to erect special ventilating tubes from their house drains to their housetops, and undertake to have charcoal placed and maintained there; but I fear the large mass of the inhabitants will not take that trouble or go to that expense: and I can scarcely conceive that domiciliary visitation by officers to an extent to insure its being done effectually would be tolerated by the inhabitants of the metropolis, largely accustomed though they now be to official interference with so many of the physical conditions of their dwellings.

The cost of adapting the existing ventilators would be about £6400 for the whole city; the cost of constructing additional ones perhaps may amount to £15,000 more; the annual charge for inspection, reparation, and renewal can be alone determined by experience; but indeed the whole question of cost cannot be approached with anything like accuracy until an experiment of some magnitude, and carried on for a length of time, be made, nor does it seem to me that the results in any way can be satisfactorily arrived at without one.

Placing the charcoal sieves before one or two ventilators as an experiment will be practically of no value whatever, for the absence of effluvium in the streets is not the only thing to receive consideration; the nuisance must be remedied, if remedied at all, without rendering the interior of the sewers more heated or dangerous than at present. Reducing the nuisance from one or two street ventilators, and remedying a small local nuisance, will help you to but little, because you have it already, upon the authority of your medical officer, that stench of every sort and description, and of any magnitude, may be destroyed by the charcoal, and what you require to know is how to apply it.

But it should be clearly understood that this system, if applied, will only remedy a portion of the evil; it may prevent the issue of stench from the street ventilators, but nothing more; it will leave the house drains and all other inlets in the same condition as at the present time. If therefore the committee consider that the result to be gained will be commensurate with the estimated cost, the proper way will be to select a limited district, adapt the existing ventilators in the first place, add to their number, and perfect the system to such an extent as may be practicable, and watch and record the results before adopting it for the whole city; and this course I beg to recommend."

ON THE PAINTING OF THE ANCIENTS.*

By F. P. Cockerell.

I FEEL, as an architect, that in bringing before an architectural society the subject of colour, which, however graceful, must be considered the least important branch of architecture, rather than the graver considerations of form, proportion, composition, &c., I owe some apology; but, as a lover of the picturesque, and having in my travels given some attention to painting in its various branches, I venture to offer you some remarks upon this highly attractive branch of our art.

Though colour is not in all cases indispensable to architectural effect, yet its value cannot be doubted as affecting architecture in general, and the true understanding of its application is hardly less difficult than that of the more serious branches of the art. Yet it must be remembered that the great masters of architecture whose works are our text-books,—Alberti, Vignola, Palladio, Phillibert, de l'Orme, &c.—have treated it as a comparatively secondary art, in a measure separated from the more grave consideration, and leaving it to the painter and the decorator.

Vitruvius speaks of it at considerable length (7th book, cap. v. to xiii.), but it is in reference to interior and not at all to exterior decoration. This distinction is of the greatest importance to mark in considering the application of colour, for upon it the chief merit of the question may be said to turn.

The use of colour in interiors has been adopted in all times and countries, and the reasonableness of the practice cannot be doubted; but in the best times of art, in the northern countries, its use in exteriors has been rejected in a great measure.

The consideration of the subject of polychromy is of comparatively recent date: it is now the fashion of the day, and let us beware how we abuse it, or attempt to hide by ornament the want of art, subverting the practice of our forefathers, and attempting pedantically to introduce into our own practice that of countries whose conditions are entirely different from our own.

Therefore, in treating the subject of ancient polychromy, I do not mean to advocate its adoption in this country, but rather by considering the works of the ancients, those great masters of common sense, to endeavour to follow their reasoning, which is so admirably adapted to their conditions and climate, to draw some conclusions with reference to our own.

All good art may be said to be a translation, more or less direct, of the book of nature, and there is no chapter in that book so largely treated, or so imperatively forced upon our consideration, as that of colour. Nature is lavish of colour in all her works, and delights the eye with her harmonies in all her operations: from the golden glories of the rising or setting sun, to the pencillings upon the back of the tiniest beetle, all is harmonious and all variety.

The whole face of nature speaks to the lover of the beautiful by colour in the earth, in vegetation, in animal creation, and in the endless variation of accidental colour, in sunlight or in clouds. Even the unseen depths of the ocean are full of objects exquisite in colour—seaweeds, shells, and the glorious rainbow hues of fishes.

And the various objects of creation have further varieties in their own species. In man, how various are the combinations of colour: the dark hair and olive complexion, the blonde hair, blue eyes, and ruddy skin, the rich auburn and the golden red;

* Paper read at the Architectural Museum.

Digitized by Google

and the true artist will surely set aside the conventional contempt of dark skin, and will find in the negro and the Indian subtleties of colour hardly inferior to our own.

So lavish is nature in her distribution of colour, that she does not confine it to her own works, but even to the conventional works of man she imparts by a few years of exposure to her influences of atmosphere and climate, a complexion whose harmony no art can approach.

From the poles to the tropics all is colour, but as nature has varied the conditions of climate and situation, so she has graduated her distribution of colour.

In the poles, amid eternal snow and under a pale sky, nature has made all her objects pale or white,—there is no brilliant vegetation—birds and animals are all grey and white, and offer but little contrast to the surrounding scene. As we advance towards temperate climates, we find bright vegetation, and a greater variety and deeper colour in animal creation. In those countries where the sky is always blue, there is a further increase in colour, until finally in the tropics we find gorgeous flowers and brilliant birds, and great jewelled butterflies, dazzling to the northern eye. But, however opposite are the combinations of colour in the poles or in the tropics, the result is the same—harmony.

And this harmony, established by nature in each latitude, affects the eye of the inhabitants, and the result shows itself in their habits, and in their choice of colour in dress, and in all objects of every-day life.

When an untravelled person sees a case of South American birds, or hears a description of the gorgeous colouring of the jungle swamps, he imagines that such contrasts of colour cannot be otherwise than discordant; but the sober greens and greys of the north, his model of harmony, would appear tame and colourless under a southern sun.

Everyone who sees with a painter's eye will have observed that the relative value of contrasting colours under a grey or neutral light, and under a brilliant sun, are absolutely changed; and that contrast which, upon a cloudy day, would appear harsh and discordant, is subdued and harmonised by the rays of the sun. Besides, sunlight introduces a new element into colour—namely, light and shade, with its endless variety, from the cold-cast shadow lighted by the blue sky, to the warm reflection from a lighted surface; so that local colour loses a portion of its importance, and contrasts become less violent.

This is a consideration of the greatest importance in judging of the system of colour adopted in those countries where polychromy took its rise and reached its maturity, and which are now more particularly under our consideration.

Besides, in those countries the blue sky, the varied hues of the mountains, the sea, &c., form a background so brilliant that, unrelieved with harmonious colour, white in architecture would be ghostlike and crude.

Having then prefaced with these considerations, and recognised nature as our mistress and the source and fountain of all our inspirations, following her by analogy and not by direct imitation, let us proceed to consider the works of the ancients, and compare them as best we can with nature.

It is not our province here to attempt to deduce from her countless varieties any system, or to establish any rules, to reduce the infinite within the compass of the finite. This has been frequently and most ingeniously attempted by different authors, but the result has been necessarily insufficient, and such, that the first natural object that came to hand would furnish an exception to the rules laid down.

The prism is a measure that lays open to us nature's system of colour; but it is in itself a disquisition so profound that we can add nothing to it, nor can we vary it so as to suit our various requirements. Without stultifying its harmony, we must therefore humbly accept it as it is, acknowledging that we are incapable of appreciating all that it teaches, and that to imitate what we do appreciate is infinitely beyond our limited means of execution. A satisfactory theory, therefore, is a thing unattainable; let us, therefore, attempt to lay one down, but let us reverentially turn to the works of the great fathers of art, and endeavour, by following their progress from the earliest times, to discover—first, whether their works do agree with our hypothesis; and if so, what may have been their interpretation of nature's teaching.

We cannot pretend positively to follow the reasonings of the ancients, or to look with their eyes into the book of nature. It is possible that we may imagine analogies with nature where none were intended; but if such analogies can reasonably be instituted, it is some proof of the correctness of the principle contained in the work of art (and if the work be good, *vice versâ*). I would therefore only suggest, in following the development of art, such points as appear to agree with our hypothesis.

The earliest style of pictorial decoration known to us is that of the Egyptians. We shall, no doubt, find in their works a certain following of nature; but the analogy with her goes no further than that first principle which dictates that there shall be colour in everything. The mode of producing this colour is for the most part by copying of natural objects—as birds, beasts, serpents, &c., or heroic or domestic subjects. No doubt these early paintings (to the repetition of which tradition bound the Egyptians of even the later times) were the nearest approach within their limited means to a direct imitation of those objects. And though we must not lose sight of the fact that these objects were naturally chosen as entering into their religion, the comparative scarcity of conventional ornament, or the absence of a regular system of lines adapted to architectural forms, seem to show a rudimentary state of art.

Those ornaments which are conventionalised are still closely imitated from nature, as the lotus cap, the papyrus, the palm, &c. And though this cannot be considered otherwise than a merit, I point to it only in contradistinction to the refined conventionality of the Greeks.

The colours used are glaring, and in crude contrast, without gradation or harmony. The modesty of nature is lost sight of, and her principle of universal colour interpreted by the use of universal paint.

I pass over thus briefly the Egyptian period, because, although the art of the great times had its origin in the teaching of Egypt, there is very little in itself that shows a high artistic cultivation, or that can serve as an example for us. The striking quality of the monuments of Egypt is of another, and indeed of a higher order—namely, simplicity and greatness of material and of execution, which conveys such a sense of the mechanical power of the people who produced them.

The next period of art—namely, the Greek—may be said to embrace, if not the birth, at least the first forward step, the progress and perfection, the decline and extinction of Classical taste.

It is in the Greek works that we find the first germs of that taste which reached its culminating point in the age of Pericles; and the art of the Romans, however debased, is still formed upon the Greek traditions, which were handed down till the deluge of barbarism swept away what little of good remained, and sowed the seeds of another style, which, faithfully following nature, as the Greeks had done before, ran a course not less glorious than them.

We have mention in history of periods of whose art no vestiges remain. Traditions, repeated by Diodorus and other authors, speak of the works of the first Dædalus (for three are mentioned at various times). Some antiquaries have endeavoured to give a reality to this mythic father of Greek art, and have supposed him to be a contemporary of Theseus, and placed his existence in the fourteenth century before our era. Probably he is simply an ideal impersonation of art, as Theseus no doubt may be of the heroic character. But this is mere curious antiquarian speculation, and has no bearing upon the history of art.

Of the earliest Greek works known to us, perhaps the most important are the temples of Selimentum, in the south of Sicily, This great and flourishing Greek colony was founded about the year 650 before our era, and was destroyed in 409 B.C. There are seven temples remaining, and the best authorities consider that the first and the last of them are about parallel with the commencement and end of its existence.

I cannot speak positively of any remains of colour in the architecture of the earliest of them, but there can be no doubt that there was colour, from the fact that the metopes are painted.

There are very distinct remains of colour in the other temples. The Duke of Serradifalco, in his work upon the temple of Selimentum, says,—"The excavations carried out in the temple E, and the œdicule B of the Acropolis (see his work, plate 2) gave new and more evident testimony of this sort of ornament. There remains of the first many trunks or columns coated with the finest white plaster, and one of them still retains three horizontal zones, each of which is successively painted with red, white, and blue. The listel of the architrave is red, that of the guttæ blue.

Digitized by Google

The triglyphs painted blue upon the face with black channels. The astragal (?) of the capitals red; and to the posticum of this temple belong certain mouldings in terra-cotta of a yellowish colour, with frets and other ornaments painted in red and dark grey. From various fragments we learn that, as in the Parthenon, the ground of the metopes is blue; and upon the arm of the female figure (plate 32 of the work) one discovers some traces of red, which colour as well as blue is much more clearly discoverable in a fragment of drapery found in the posticum of this temple. Nor should we here omit to mention the very singular circumstance that we find the cap of one of the triglyphs first painted red upon the stone, afterwards coated with stucco, and at last repainted with the same colour. We have more important remains of the œdicule B, namely,—the trabeation of the south-west angle, one of the lions' heads of the cymatium, in which there remains still the sinking prepared to receive it; one angle and various fragments of the pediment, the whole cap of the ante, the lower portion of the shaft of a fluted column, with part of its Doric cap, and several fragments of minor importance. From the observations made upon these remains we find that the whole fabric was coated with a very fine stucco of a pale yellowish colour, the listels of the architrave, of the bed-mould, of the corona, and of the mutules; the last blue with white guttæ, blue also are the triglyphs and their fascia, which is divided into two by a very fine line. The capital and what remains of the ante is of a yellowish tint, and all the sunk lines are marked with a fine black line, so as to give more effect to the other mouldings."

M. Hittorff, a received authority upon the antiquities of Sicily and author of the ingenious work 'L'Architecture Polychrome chez les Grecs,' goes much further, and launches very far into the ideal. Indeed he does not pretend to confine himself to the facts found in the ruins of this temple, but unites fragments and authorities from other temples in Sicily and elsewhere to produce his ideal of the Greek system of Polychromy. Perhaps his enthusiasm may have carried him somewhat beyond the bounds of probability in his opinions. A reference to this work, and to that of Serradifalco, will enable those who are interested to judge how far his opinions are borne out by reason and by facts.

The temple of Jupiter, in the island of Egina, supposed to be about forty years earlier than the last of the temples of Selimes, which in architectural proportion and refinement is a step in advance of those of Selimentum, still show very clear traces of colour.

The best authorities have established that the triglyphs were painted blue, the tœnia red, the mutules blue; their fillet and the rest of the soffit of coronæ red; the cymatium enriched with a honeysuckle in gold; several mouldings and the soffit of portico painted, &c. There is no evidence, nor do the best authorities conjecture that the broad surface, the shaft and caps of columns, or the wall of cella, were painted.

The large patches of blue presented by the triglyphs appear crude and unhappy, and little in accordance with the refined taste of the artists of Egina, but we find an explanation of this in Vitruvius, where he tells us that in the early wooded constructions the ends of the beams (the triglyphs) were covered with a board painted with blue wax to preserve it from the action of the weather; and, as we find in other temples where there are traces of colour, that the triglyphs were likewise blue, it is clear that this ancient practice was carried into later times, as a tradition which popular prejudice and a religious reverence for antiquity insisted upon preserving. In the sculptured parts there are undoubted evidences of colour; the shields and the crests of the warriors were painted red, parts of their arms and armour gilt, while the tympanum of the pediment was blue.

The frieze of the mausoleum of Halicarnassus, though of a date about 180 years later, is treated in the same way; and the last discoveries show that the lions' mouths were picked out with red.

No one can doubt the value, and indeed the necessity, of such a distribution of brilliant colour to give relief and interest to the otherwise monotonous blaze of white standing out in strong relief against the deep blue sky, and having no interest of colour to bring into harmony with the brilliant scenery.

But at this period in the progress of art, the refinement of study being directed to the perfecting of form, we may fairly suppose that where so much love and study as were required to produce the Egina marbles had been expended, the result would be considered of higher importance than colour, which, from being so constantly repeated, could scarcely have ranked with the other branches of architecture, and must have been treated as a matter of mere traditional practice, as was no doubt the case in the painting and sculpture of Egypt.

It is important to observe that in the cases of Egina and Halicarnassus the colours are made entirely subservient to the sculpture, and so distributed as to assist materially in giving relief to its forms. There is no painted detail (in the sculpture), no ornament or variety of colour to arrest and give occupation to the eye. It is the inferior and less interesting portions which are coloured, and that with uniform tints, producing that sparkle which is so essential to pictorial effect, and leaving the nobler portions—the human form divine—untouched, and indeed assisting and giving expression to them by contrast.

And here it is desirable to observe that some picking out is more an optical necessity under a southern sun than we can imagine in our tame light. Those who have studied in those countries will have found over and over again a difficulty in distinguishing forms upon a background of the same colour, from the violent contrast of intense blazing light and black sparkling shadows, which dazzles the eyes and causes the half tints to disappear. In the tangled intricacy of the frieze of Halicarnassus, being as it was at a considerable distance from the eye, this would be particularly the case.

In this principle of aiding form by colour we may find an analogy with nature in most of her works. For instance, in flowers the sinking of the calix is marked by getting darker or lighter, and the forms of shells are constantly marked in the same way. The eyebrow seems to have no other purpose than to give expression to the form of the brow, &c.

But in our own convenient works of architecture nature's working in this respect teaches a lesson in the plainest terms and in no parable. Soffits take a rich warm tint, and upper surfaces of salient parts a cold and pale grey, which comes out in strong relief against the varied tints of the vertical surfaces.

(To be concluded in our next.)

THE GREAT EASTERN.

THE preparations necessary for fitting this noble vessel for sea have at last been decided on, and will be immediately carried out. To one contractor will be entrusted the iron work still requisite in the hull and in the construction of the poop and masts, while separate contracts will provide for the rigging and sails and the cabin fittings and joiners' work. No money will be wasted in the mere frippery of decoration, though at the same time all the fittings will be of the best and most substantial kind. The design for the poop is complete in all its details. All of it will be constructed of iron, and some idea of its size may be gathered from the fact that the chief dining saloon, 120 feet long by 47 feet wide and 9 feet high under the beams, will be in that part of the vessel. There is to be a large number of bath-rooms allotted to each class of passengers, all of which will be kept supplied with hot and cold fresh and sea water. The contractors are to commence their work on the 15th instant, and are bound under penalties to complete all in five months from that date. The long-expected first trial trip will therefore take place about the middle of July, when it is intended to run out from Weymouth to the middle of the Atlantic and try the ship under all possible conditions of sail and steam. This short voyage will probably occupy about six days, for the lowest estimate yet made of her speed allows her 17 knots, or about 18½ statute miles an hour, the speed of a parliamentary train. The commencement of the work of fitting will be made by which the large iron floating Derrick launched last autumn will be used for the purpose of hoisting in the main shaft of the paddle engines and the rudder. The former weighs 40 tons, the latter 13, and each of these ponderous masses of iron work have been finished off with as much care and even neatness as if they were intended for the works of a clock. Both these will be deposited in the fore part of the vessel in order to assist in bringing her more down by the head when the blades of the screw are being fixed. The latter have not been attached to the screw bars, as in case of ice during the winter enough might have formed round them to have held such a mass of the loose pack as with the flow of the tide might have seriously endangered the ship. Trotman's anchors, by which she is now moored, would never have given way; but the chains unquestionably might.

Digitized by Google

A MODE OF CONSTRUCTING CANNON, WHEREBY THE STRAIN PRODUCED BY FIRING IS DISTRIBUTED THROUGHOUT THE MASS OF METAL.

By Capt. T. A. Blakely, R.A., M.R.I.A.*

It has long been known that increasing the thickness of metal in the cylinder of a Bramah press does not increase its strength beyond a certain point. The failure one after another of the huge presses used in launching the Leviathan, under a pressure of less than five tons to the inch, must be fresh in the memory of all; yet the thickness of metal in some of these was as much as 7½ inches, the diameter of the piston or ram being only 10 inches: the tensile force of 15 inches, two thicknesses each 7½ inches, being thus opposed to a pressure on only 10 inches. This small proportion of pressure has always been found sufficient to burst a cylinder.

The cause of this weakness, which equally affects cannon, is even now but very little known, although it was distinctly pointed out by Prof. Peter Barlow in a paper read to the Institution of Civil Engineers many years ago, and published in the first volume of their 'Transactions.' As that paper is in the library of this Institution, I need only refer to it very briefly.

Prof. Barlow proves that the outer portions of a cylinder have comparatively little strain transmitted to them, and therefore add little to its strength. He bases his argument on the well-known law,—that metal subjected to a moderate tensile strain stretches in the direction of the strain, and very nearly in proportion to it; that is to say, if 1 ton will stretch a bar of a certain length 1 inch, 2 tons will stretch it 2 inches, or 6 tons 6 inches. This is generally known as "Hooke's law" *ut tensio sic vis*, and has been found by experiment to be very nearly correct. Prof. Barlow argues that fluid pressure from within a cylinder must stretch it. That it really does so in a gun or rifle is easily proved by placing a leaden ring round one: if it fit tight before the piece is fired, it will be loose afterwards.

No known material is capable of exerting a tensile force without stretching. The amount of stretching in many materials is so well known that it can be used as a measure of the tensile force; this is the case with iron.

Now a moment's reflection must convince any one that the outside of a thick cylinder cannot stretch as much as the inside. If it did the mass of metal or other material must be increased during the strain. Let us consider, as an example, a cylinder the size and thickness of the strong part of a 10-inch gun, 10-inch bore and 10 inches metal round it; and let us imagine this cylinder to be made of homogeneous india-rubber. In this case the inner diameter might easily be stretched to double its size, becoming 20 inches instead of 10.

Now it is evident that the outside circumference and diameter cannot be doubled at the same time, or else the latter must become twice 30 or 60 inches, which would give a thickness of 20 inches, quadrupling the mass of material,—which is impossible.

A moment's reflection shows that the thickness must diminish as the circumference is increased by pressure from within; for, if the thickness remain 10 inches when the internal diameter has become 20, the external diameter must be 20 plus twice 10, or 40 inches.

This could not be, unless we imagine what seems impossible, viz., that the bulk of the material is considerably enlarged, as each inch in length of the cylinder would now contain 1200 cylindrical inches, (the difference between the squares of 40 and 20, the external and internal diameters), whereas, originally it only contained 800 inches, the difference between the squares of 30 and 10.

Yet, even if the thickness could remain the same, notwithstanding the increase of circumference, the outside layer could only be strained one-third as much as the inside one, because three times as long. The same elongation which would cause a strain of 1 ounce or 1 pound in the longer circumference would cause a strain of 3 ounces or 3 pounds in the shorter one; and the elongation which would but moderately strain the one would break the other.

This reasoning is equally applicable to the minute extension of iron; the increase of $\frac{1}{10}$ of an inch in the outer circumference of a 10-inch gun being possible without fracturing that part, being an elongation of but 1 in 940; whereas the same extension must crack the inside, as no iron could stand an elongation of $\frac{1}{10}$ in 31½, or 1 in 314.

Even on this showing, then, the outside of a thick tube cannot do its share of work; a closer examination, however, must convince us that it cannot even do thus much, for the thickness of material must diminish as the circumference is increased.

When the inner diameter of the 10-inch cylinder becomes 20 inches the thickness must diminish from 10 to 7·32 inches; the mass of material in the cylinder, and therefore its cross-section, remaining the same.

The cross-section was originally 800 circular inches, 800 being the difference between the squares of 30 inches, the outer diameter, and 10 inches, the inner; or 900 minus 100. When stretched the area of the cross-section must continue to be 800 round inches.

Now the thickness of 7·32 inches gives us an external diameter of twice 7·32 or 14·64 added to 20, the internal diameter; in all 34·64 inches, the square of which is 1200. Subtracting 400, the square of 20, leaves 800 round inches as before.

In this case the outside of the cylinder is stretched but 4·64 in 30, about 1 in 7, when the inside is stretched to double its original size.

If the inner diameter be only stretched to 11 inches the thickness must be diminished from 10 to 9·674 inches, the outer diameter becoming 30·348 inches, the cross-section remaining 800 round inches as before, the difference between the squares of 30·348 and 11. Here the outer layer is elongated ·348 in 30, or 1 in 86; whereas the inner is extended 1 in 10, showing a strain or an exertion of power 8½ times greater.

In the minute extension of metals the disproportion is still more striking. Thus in cast-iron the 10-inch inner diameter may become $10\frac{1}{10}$, which would extend the outer diameter only from 30 to $30\frac{1}{300}$, the cross-section remaining 800 inches, and the thickness diminishing from 10 inches to $9\frac{9}{10}\frac{8}{00}$ (see fig. 1). Here the outside would only be stretched $\frac{1}{300}$ in 30, or 1 in 9000; the inside being stretched $\frac{1}{100}$ in 10, or 1 in 1000, exerting therefore nine times as much power as the outside.

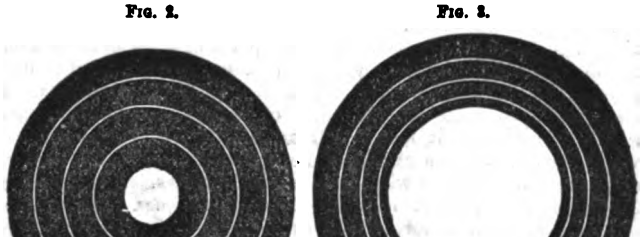
Fig. 1.



It is evident that a slight increase of pressure from within would break the inside, while the outside could help but little in restraining the disruptive force.

If we make equidistant circular marks on the end of an india-rubber cylinder (fig. 2), and stretch it, we can see plainly how much more the inside is strained than the outside or even the intermediate parts. The spaces between the marks will become thinner, each space becoming less thin than that inside of it, and the inner space *much* thinner than the others (fig. 3), showing that when the inside is strained almost to breaking the intermediate parts are doing much less work, and those far removed almost none.

Fig. 2. Fig. 3.



The law (see Note A, p. 48) deduced by Prof. Peter Barlow in the paper referred to, is that in cylinders of metal the power exerted by different parts varies inversely as the squares of the distances of the parts from the axis. The following table shows the elasticity exerted according to this law by the different concentric layers of metal in a gun where the thickness is one calibre and divided into ten imaginary equidistant portions, E being that of the inner part of all, E_1 that of the part one-tenth of a calibre from the inner surface, E_2 two-tenths, &c.

* From the 'Journal of the United Service Institution.'

Digitized by Google

$$E = E \qquad = 1{\cdot}0000\,E$$

$$E_1 = E\frac{c^2}{c^2(1+\frac{2}{10})^2} = E\frac{100}{144} = 100\,E \times = \frac{1}{144} = {\cdot}6944\,E$$

$$E_2 = E\frac{c^2}{c^2(1+\frac{2}{10})^2} = \qquad 100\,E \times \quad \frac{1}{14^2} = {\cdot}5102\,E$$

$$E_3 = 100E \times \frac{1}{16^2} \qquad = {\cdot}3906\,E$$

$$E_4 = 100E \times \frac{1}{18^2} \qquad = {\cdot}3087\,E$$

$$E_5 = 100E \times \frac{1}{20^2} \qquad = {\cdot}2500\,E$$

$$E_6 = 100E \times \frac{1}{22^2} \qquad = {\cdot}2066\,E$$

$$E_7 = 100E \times \frac{1}{24^2} \qquad = {\cdot}1736\,E$$

$$E_8 = 100E \times \frac{1}{26^2} \qquad = {\cdot}1479\,E$$

$$E_9 = 100E \times \frac{1}{28^2} \qquad = {\cdot}1275\,E$$

$$E_{10} = \frac{1}{9}E = 100E\frac{1}{30^2} \qquad = {\cdot}1111\,E$$

Thus we see that in a 10-inch gun, when the inside—which is 5 inches from the axis—is fully strained, the metal 2 inches from the inside, or 7 inches from the axis, can only exert a force $\frac{25}{144}$ or little more than half as much; 3 inches further, 10 inches from the axis, the force exerted diminishes to $\frac{25}{100}$, or but a quarter of that exerted by the inside; and if the gun be 12 inches thick the outside, which is 17 inches from the axis, can exert but $\frac{25}{289}$, or about $\frac{1}{12}$ as much power as the inside. Of course casting the gun still thicker would add but very little to its strength; we cannot therefore be astonished that it has been found in practice that cylinders for hydraulic presses with a thickness equal to about half the diameter of the piston are very nearly as strong as if ten times as thick.

In 1855 Dr. Hart, of Trinity College, Dublin, investigated the problem. His calculations (see note W, p. 259, of Mr. R. Mallet's work on the Construction of Artillery) gave greater strength to the inner parts, but still less to the outer, than those of Prof. Barlow. Both these gentlemen (see Note B), as well as General Morin and Dr. Robinson, the astronomer, who have also studied the question, agree that no possible thickness can enable a cylinder to bear a pressure from within greater on each square inch than the tensile strength of a square inch bar of the material; that is to say, if the tensile strength of cast-iron be 6 tons per inch a cylinder of that metal, however thick, cannot bear a pressure from within of 6 tons per inch. This has been found practically true with hydraulic presses, and indeed with guns also, a 32-pounder being the largest which can with safety be fired with a full charge of powder.

It may perhaps aid in impressing the truth of the theory of the almost perfect uselessness of the outer parts of thick cylinders on the minds of some of my audience, if I describe how it was discovered by myself, and how before me by Sir Charles Fox. I was seeking to evade the difficulty of casting very large masses sound and strong; it being well known that iron when cooled very slowly (as when cast in large masses) crystalises coarsely, and is not so strong as when cast in smaller sizes. I wished also to be able to transport monster mortars in pieces. With these objects I planned a mortar consisting of several concentric mortars, not fitting closely throughout, but only at their mouths or open ends. The spaces between them I intended to fill simply with water or oil, which (all apertures being closed hermetically) could transmit the strain quite as well as metal, being perhaps even more incompressible. In considering the manner of this transmission of strain by the film of water, it seemed evident to me that it could only receive the pressure from the interior by the inside metal being pushed against it,—that is to say, by the particles of the inner cylinder changing their position, and some of them occupying (during the continuance of the strain) a portion of the space before occupied by the water; the film of water changing its position and pushing outwards some portions of the outer cylinder, these again pushing away portions outside of them. I can conceive no other way by which transmission of pressure can take place but by such "pushing." It at once occurred to me that the cylindrical film of water in the necessary change of position would be enlarged in diameter very sensibly; for instance, in a 40-inch mortar, with the sides of the inner cylinder 5 inches thick, the film of water around it would be about 50 inches in diameter, and, fully to strain the metal outside of it, must acquire a diameter of $50+\frac{50}{1000}$, or $50\frac{1}{20}$ inches. Without such an enlargement the outer metal could not be fully strained, strain without proportionate stretching being impossible, and $\frac{1}{20}$ of an inch being the elongation necessary in a 50-inch bar when exerting its greatest power consistent with safety. Now, it is evident that a film of water increasing in circumference three-twentieths of an inch must decrease in thickness, the quantity of water remaining the same. Exactly the same increase of circumference and decrease of thickness must take place in the metal of a press or cannon, but this had never occurred to me till I thought of the water transmitting the strain. A calculation in the difference of the amount of work done by the outside and inside of a thick cylinder was easily made, and certainly the result astonished me. It seemed so improbable that such a thing should have remained unknown. Much greater was my astonishment when I heard that Prof. Peter Barlow had made the cause of the weakness in cylinders public many years ago, but that his paper on the subject was utterly neglected.

Sir Charles Fox made the discovery by a process exactly the reverse of mine. He observed the effect first, I the cause. Many years ago he was making a suspension bridge to be sent to Russia. The chain was to be formed of bars of iron bolted together through holes at their extremities. The size of the bolts had to be determined by experiment. The first bars were made 4 inches wide, the holes (and bolts) being only 3 inches, and the metal round them 5 inches, seeming the strongest part.

Fig. 4



This thickness was given to admit of being reduced if the 3-inch bolt proved to be too weak. Three bars were bolted together, two in one direction, the third between them and in the other direction. They were then strained, and, instead of the thin bolt breaking, the bars gave way at the part where they seemingly had 10 inches to resist rupture. This always took place in the same manner, viz., from the inside of the eye or bolt hole (fig. 4). Thoroughly to investigate this strange phenomenon, Sir Charles had straight lines cut in two directions at short intervals across the face of the bars near the bolt. He took an impression of these on a sheet of paper by rubbing a soft lead-pencil over it, as one copies monumental brasses. The bar was stretched a little and another copy taken, a little more and another copy; and so on, till a complete history of the motion of each particle was before the ingenious investigator. This history showed that the inner (and therefore the shorter) fibre broke before the outer one sensibly stretched at all. Until Sir Charles Fox with great kindness told me of this practical investigation, I confess I almost doubted the truth of the merely geometrical solution of the problem. I trust I have been able to convince others that in a thick cylinder (like a cannon) the outside can take only—I will not say one-twelfth, as I myself believe, but—one-sixth of its share of work, an amount which could not be transmitted to it without an increase of $\frac{1}{2000}$ in the bulk of the cylinder, or a diminution to that extent in its length.

If this be the case with long-continued pressure (which we have been considering), what must it be when the pressure is applied and removed almost instantaneously, as in a gun? If the gun were thick enough and very short, the pressure might have absolutely passed from the inside before it reached the outside at all. In estimating the value of the present system of constructing guns we must bear in mind also that the outer half-inch weighs about three times as much as the inner. One-sixth

Digitized by Google

its share of work by thickness is therefore only one-eighteenth by weight. One ounce of metal at one part does more than seventeen ounces at another.

My arguments have often been met by the query,—How is it that guns and Bramah presses stand so well as they do? To this I answer that Bramah presses do not stand, and the work performed by guns has always been much over-estimated. For instance, in a smooth-bored musket the annexed table shows that the pressure can never have been 300 atmospheres, or 2 tons to the square inch.

Table of Experiments made by Mr. Piobert to determine the Initial Velocity of Shot fired from Guns of different Lengths, and deductions from them by the Author.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length of Gun.		Space passed through by the shot.	Total velocity acquired	Velocity added.	Space in which the latter velocities are added.	Times in which the latter velocities are added (in millionths of a second).	Total time in millionths of a second.	Pressure, if uniform, on shot from behind necessary to add the Velocities in col. 5, during the Times in col. 7.	Pressure of the gas on a surface the size of the section of shot necessary to move the gas itself with the velocities in column 4.	Mean resistance from the air in front, and friction.	Total pressure per sq. inch in atmospheres.	Number of times the size of the cartridge occupied by the gas.	Pressure in atmospheres which would result from compressing the gas into the space occupied by the cartridge.	Supposing the gas at the heat of ignition to fill 3000 times the space of the cartridge, proportion of powder burnt.
In calibres.	In inches.													
		Feet.	Feet.	Feet.	Feet.			lb	lb	lb				
4	2·7	·06'6'	300	300	·06'6'	450	450	1278	3·6	2·3	257	1·75	450	·150
5	3·3	·116'	390	90	·050	145	595	1161	6	11	236	2·25	531	·177
7	4·7	·233'	540	150	·116'	251	846	1120	11·5	31	232	3·25	754	·251
11	7·3	·450	740	200	·216'	338	1184	1109	22	58	237	5·25	1244	·415
16	10·7	·78'3'	870	130	·283'	352	1536	638	30	89	151	8	1200	·400
22	14·7	1·06'6'	950	80	·333'	366	1902	450	36	113	120	11	1320	·440
29	19·3	1·450	1050	100	·383'	383	2285	489	44	143	134	14·5	1928	·643
38	25·3	1·950	1160	110	·500	450	2735	458	54	173	137	19	2600	·866
49	32·7	2·550	1250	90	·600	500	3235	337	62·5	198	120	24·5	2940	·980
64	42·8	3·400	1253	3	·850	680	3915	8	62·6	214	57	32	1824	·608

The bullet weighed 15 drachms = ·06 lb. The powder occupied about 1·4 inch in length.

The first four columns are the data obtained by actual experiments with muskets of various lengths. The 4th column shows the velocity acquired by the bullet in passing through the spaces recorded in the 3rd column. Now, these quantities and the weight and size of the bullet being known, it is easy to calculate the pressure, &c. (Note C.) Column 12 gives the pressure in atmospheres for the different portions of a long musket, 257 being the maximum.

The simplest way of verifying my calculations will be to assume a pressure of 300 atmospheres, or two tons per inch, and find the velocity this would produce in bullets from muskets of the different lengths. The velocities thus found will much exceed those found by experiments, proving that the pressure, as I said, never reaches that amount. As the size of the gun increases, however, the pressure of the gas of the powder increases; for whereas the musket-ball in moving, say 4 inches, has left a space for the powder seven times its original size (if the cartridge be about the size of the bullet), a 9 lb. shot in moving 4 inches only leaves a space of double the size of the cartridge.

Thus a shot of extremely large dimensions would move so slowly that the powder could all be turned to gas, while the space left free for it would scarcely exceed its original dimensions. According to the most reliable theory, that of Capt. Boxer, the pressure then would be 3000 atmospheres, or 20 tons to the square inch.

We do not know the exact time required for powder to burn. In a musket (see table) it took $\frac{1}{100}$ of a second, during which time the bullet moved 30 inches, but what the time required in large guns is we do not know.

We do know, however, that a 32-pounder is the largest English cast-iron gun which can fire double shot with full charges. We may therefore assume that in it the pressure acting during the short time has about the same straining effect as the continued pressure of between 4 and 5 tons to the square inch, which we found to be the maximum a cast-iron cylinder could bear. We may also assume that in a 68-pounder the strain exceeds that amount.

Before proceeding further it is necessary to show what effect a pressure of 4 tons per square inch would have on different sized shot, for if the known effects exceed those which that pressure can produce, my theory must be abandoned.

The well-known formula

$$V^2W=2PGS$$

gives us the information that a pressure of 4 tons per inch on a 9-pound shot would produce a velocity of 1600 feet per second in a space of about 40 inches, less than half the length of a gun; that the same pressure would produce the same velocity in a 32-pound shot in a space of about 60 inches (the naval 32-pounder being 120 inches long), and in a 68-pound shot in 80 inches. This proportion in the 68-pounders would lead us to the correct conclusion, either that the guns must be made stronger or the velocity of 1600 feet must be sacrificed. The latter is the course adopted, a smaller proportion of powder being used in a 68-pounder than in a smaller cannon. The velocity of 1200 feet per second, which is actually attained, could be produced by a pressure of 4 tons in a space of 45 inches.

Having thus shown that a pressure of 4 tons per inch can produce greater results than we know are produced, and having proved that cast-iron cylinders (Note D) cannot bear a greater pressure, I think it remains with those who maintain that the pressure is greater to prove that it is so, and to account for the velocity of the shot not being in proportion to such great pressure as they assert to be developed.

We much want a stronger 68-pounder and 10-inch gun, and must therefore seek some other method of construction than casting them of iron. Steel guns have not yet succeeded on a large scale, and, if they did, it would be a pity to use so valuable a material so unscientifically that one part shall be strained to breaking while another is idle. The same may be said of wrought-iron.

The remedy I would venture to suggest for the equal strain on different parts of the thickness of a gun is extremely simple. Several parts should be made to take a moderate share of the strain, instead of the inside having too much and the rest of the gun too little, as in the cast gun; or the inside none and the middle too much, as in the old mode of manufacture with hoops and staves of iron. One glance at a section of a gun (fig. 5) of the latter construction will suffice to convince us of the futility of the attempt lately made to reintroduce it. It has nearly all the defects of a cast gun, particularly that of the unequal straining of its parts, besides others peculiar to itself,—the penetration of the gas between the staves for instance.

Fig. 5.



A more equal distribution of strain can only, I think, be secured by building guns of concentric tubes, each slightly too small to be placed over the one below it without force. The difference of size necessary is easily calculated with sufficient exactness for practical purposes. The greater the number of layers the greater the strength; as, by a minute subdivision, all parts doing but one-half their share of work or less can be replaced by metal capable of exerting nearly its whole force with so small an additional extension as not to render an undue extension of any other part necessary.

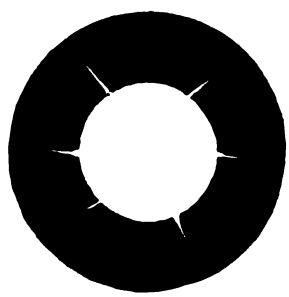
Digitized by Google

A very simple way of making a great number of parts each exert an equal amount of power, is to wind wire around an inner tube, with a tension increasing with each layer.

Very shortly after I took out my patent for this mode of constructing cannon, Mr. James Longridge, an eminent civil engineer, took out one for manufacturing hydraulic presses in the same way. He made several experimental cylinders, and some, with sides but one-third as thick in proportion as those of a gun, were filled with gunpowder, closed hermetically with the exception of a small vent, and without injury bore the shock of the explosion of the contained powder.

The pressure cannot have been less than 15 tons per inch, an amount which certainly the tubes could not have borne for a much longer period. These cylinders had flanges to keep the wire on. Some of these gave way, as shown in fig. 6, the cracks being much more open at the inside, and some not extending to the outside; thus proving how comparatively little the latter was strained, and fully corroborating Sir C. Fox's experiments.

Fig. 6.



Mr. Longridge has lately made a 6-inch cylinder for a Bramah press, which, with sides of $\frac{3}{4}$ of an inch of cast-iron, covered with $\frac{1}{2}$ inch of wire (ten coils of one-sixteenth inch wire), has borne a pressure of 7 tons to the inch,—a much greater proof than ordinary cylinders of treble thickness are subjected to.*

Although a greater number of layers of tubes gives greater strength, still much benefit arises from the division of the metal even into two. I made a 9-pounder gun of two layers—the inner one 4 inches in bore and $10\frac{1}{2}$ inches in outer diameter—cylindrical from the breach to the trunnions. Over this I put another layer, about one-hundredth of an inch less than $10\frac{1}{2}$ inches in inner diameter, so that it had to be heated to make it pass over the other part. The outer tube I made of wrought-iron, and for convenience of four pieces. When finished the gun had exactly the appearance of an ordinary one, and was about the same weight as the service cast-iron gun; against one of which, as well as a brass service gun, and one made by Mr. Dundas, of Dundas (of wrought-iron staves hooped together), mine was tried at Shoeburyness, by order of the Ordnance Select Committee, in 1855 and 1856. The four guns were fired as follows :—

2	rounds	with 8 lb.	of powder	and 2	shot.
86	,,	3	,,	1	,,
26	,,	4	,,	1	,,
5	,,	5	,,	1	,,
5	,,	5	,,	2	,,

So far all four remained serviceable. The charge was increased to 6 lb. of powder and two shot, with which Mr. Dundas's gun burst at the third round; the service cast-iron gun burst at the 110th round; the service brass gun became unserviceable after 174 rounds; but my gun was so sound after 318 rounds, that the charge was increased by one shot at a time till the gun was loaded to the *muzzle*, in which state it was fired 158 times before it burst!

This astonishing endurance must not be attributed to the mere substitution of wrought for cast iron in the outer inch-and-a-quarter. The mere change of material added but $\frac{1}{7}$ as much strength as the change in the *size* of the outer layer; for without this adjustment of size the wrought-iron could not have exerted its power,—as when the inner metal was fully strained, and the diameter of the bore increased from 4 to $4\frac{1}{100}$ inches, the diameter of the outside of the inner layer could be extended only from $10\frac{1}{2}$ inches to $10\frac{1}{2}+\frac{1}{666}$ inches,—1 in 7000. With such a slight enlargement, the outer layer could not be pressed against enough to enable it to exert its full force,—good wrought-iron extending 1 in 7000 with a tension of $1\frac{1}{2}$ ton per inch. By making the outer layer $\frac{1}{100}$-inch less in diameter originally, I secure, that when the outside of the inner tube stretches $\frac{1}{700}$-inch, the outer tube shall be extended $\frac{1}{100}$ added to $\frac{1}{700}$, or $\frac{1}{87}$-inch, being 1 in 900, the elongation due to an exertion of power equal to $10\frac{1}{2}$ tons, seven times greater than the mere substitution of wrought-iron could give. (See note E.)

In a 68-pounder the strength of two layers will probably suffice, but for larger guns more of the metal must be made to take a fair share of work, and therefore more concentric tubes used. Care must be taken to have sufficient longitudinal strength. For this purpose some circumferential strength may well be sacrificed, by casting one part the length of the entire gun and of adequate thickness.

For various reasons it seems better that this single large piece should be the inside, cast-iron being admirably suited for the bore of a gun, whereas wrought-iron generally has some defect in the welding which would certainly be penetrated by the gas of the powder. In some cases—for instance, in breech-loading guns—it may however be preferable to have the longitudinal strength outside. The latter construction has the advantage of giving greater circumferential strength; for (strange though it may seem) an ordinary cast gun, whether of iron or brass, would be strengthened at the breech by removing one-quarter of the thickness from the inside, and replacing the metal with even lead or pewter. The reason of this apparently paradoxical increase of strength is, that each remaining portion could do more work without any part giving way, in the proportion of 9 to 4, when the inner part (which must yield first) is larger than as at present in the ratio of 3 to 2 (Note F). The gain of power by thus permitting the outside to exert more of its force is greater than the loss by removing the inner parts, which must have cracked before the outer could be moderately strained. A brass lining near the breach of a gun would evidently add much to its strength. This would also be a convenient way of strengthening mortars already cast.

With the exception of the single large piece for longitudinal strength, the gun may with advantage be formed of a number of small tubes accurately put together. Mortars, which are seldom subject to the fire of an enemy, cannot be more easily and strongly made than of wire wound with proper tension round an inner tube of brass, steel, or iron.

Mr. Longridge made a wire gun weighing but 3 cwt., from which he obtained ranges of 1500 yards with a 9 lb. shot. The service brass 9-pounder weighs 13 cwt.

A wire-strengthened gun made with these proportions could bear any strain gunpowder could directly cause. I can therefore see no reason why a solid shot weighing a ton should not be thrown eight miles from such a gun.

A gun formed principally of cast-iron, and reinforced near the breech with three layers of tubes forced on (I should prefer wrought-iron or tough steel for the latter), may seem stronger than necessary near the breech, but it must be borne in mind that it is only there that the largest guns are more strained than the smallest.

In various other obvious ways my object can be effected. This object is—So to construct guns that at the moment of firing the greatest possible proportion of the thickness of metal shall be nearly equally strained.

In consequence of the wonderful endurance of my 9-pounder, the British government is now trying experiments with an 8 and a 10 inch gun of the same construction. It is expected that an 87 cwt. 10-inch gun can be made capable of firing solid shot of about 130 lb. For this purpose the metal should have been distributed differently, a greater thickness being given to the breech end: however, I anticipate a successful result even from the gun now at Woolwich on the pattern of the ordinary shell gun.

(To be concluded in our next.)

* This press was exhibited and explained after the lecture by Mr. James Longridge.

Note A.

The following are the Professor's own words:—"It would appear at first that, having found the strain at D and C, it would only be necessary to ascertain the thickness of metal necessary to resist this strain when applied directly to its length. This however is by no means the case, for if we imagine, as we must do, that the iron in consequence of the internal pressure suffers a certain degree of extension, we shall find that the external circumference participates much less in this extension than the interior, and as the resistance is proportional to the extension divided by the length, according to the law *ut tensio sic vis*, it follows that the

Digitized by Google

external circumference, and every successive circular lamina from the interior to the exterior surface, offers a less and less resistance to the interior strain;—the law of which decrease of resistance it is our present object to investigate.

"In the first place it is obvious that, whatever extension the cylinder or ring may undergo, there will be still in it the same quantity of metal; or, which is the same, the area of the circular ring formed by a section through it will remain the same, which area is proportional to the difference of the squares of the two diameters.

"Let D be the interior diameter before the pressure is exerted, and $D+d$ its diameter when extended by the pressure. Let also D′ be the external diameter before, and $D'+d'$ the diameter after, the pressure is exerted. Then from what is stated above it follows that we shall have

$$D'^2-D^2=(D'+d')^2-(D+d)^2, \text{ or,}$$
$$2D'd'+d'^2=Dd+d^2, \text{ or,}$$
$$2D'+d' : 2D+d :: d : d';$$

or, since d' and d are very small in comparison with D′ and D, this analogy becomes $D' : D :: d : d'$. That is, the extension of the exterior surface is to that of the interior as the interior diameter to the exterior.

"But the resistance is as the extension divided by the length, therefore the resistance of the exterior surface is to that of the interior as $\frac{D}{D'} : \frac{D'}{D}$ or as $D^2 : D'^2$. That is, the resistance offered by each successive lamina is inversely as the square of the diameter, or inversely as the square of its distance from the centre; by means of which law the actual resistance due to any thickness is readily ascertained.

"Let r be the interior radius of any cylinder, p the pressure per square inch on the fluid, t the whole thickness of the metal, and x any variable distance from the interior surface. Let also $rp=s$ represent the strain exerted at the interior surface, according to the principles explained in the preceding part of this paper. Then by the law last illustrated we shall have

$$(r+x)^2 : r^2 :: s : \frac{r^2 s}{(r+x)^2}$$

for the strain at the distance x from the interior surface, and consequently

$$\int \frac{r^2 s\,dx}{(r+x)^2} + \text{Cor.}$$

=the sum of all the strains, or the sum of all the resistance. This becomes, when $x=t$,

$$R=r^2 s\left(\frac{1}{r}-\frac{1}{r+t}\right)=s\frac{rt}{r+t}$$

That is, the sum of all the variable resistances due to the whole thickness t is equal to the resistance that would be due to the thickness $\frac{rt}{r+t}$ acting uniformly with a resistance s, or rp.

"*Application of this Rule for computing the proper thickness of metal in a Cylindric Hydraulic Press of given power and dimensions.*

"Let r be the radius of the proposed cylinder, p the pressure per square inch on the fluid, and x the required thickness. Let also c represent the cohesive strength of a square inch rod of the metal. Then, from what has preceded it appears that the whole strain due to the interior pressure will be expressed by pr, and that the greatest resistance to which the cylinder can be safely opposed is $c\times\frac{rx}{r+x}$: hence, when the strain and resistance are in equilibrio, we shall have

$$rp=\frac{rx}{r+x}\times c \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

or $pr+px=cx$, whence $x=\frac{pr}{c-p}$, the thickness sought."

NOTE B.

Dr. Hart's formula for the pressure a cylinder can bear is

$$p=t\frac{R^2-r^2}{R^2+r^2} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where p is the pressure on each square inch of interior surface, t the tensile force of a square inch bar of the material, R the radius of the outer surface of the cylinder, and r that of the inner surface or bore. Using this notation, Prof. Barlow's formula (1) is

$$p=t\frac{R-r}{R} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

These equations become identical when R is indefinitely large compared with r, then $p=t$; which means that an *infinite thickness* of metal is requisite to bear a pressure on each inch of the bore equal to the tensile force of a square inch bar of the metal; yet a thickness equal to the radius of the bore would suffice if each particle were equally strained.

NOTE C.

The experiments were made with guns of $\frac{3}{4}$-inch bore and different lengths, firing a bullet of 15 drachms=·06 lb., the powder occupying about 1·4 inch of the bore. The object was to find the effect of the length of the gun.

The first four columns are the data from which I have calculated the rest.

The 5th column is simply the difference between the velocities at the beginning and end of the spaces mentioned in the 6th column, which is deduced from the 3rd by subtracting from each line that preceding.

The times in the 7th column are found on the supposition that the pressure during each short interval is constant (which it is very nearly), by the following formula: $t=\frac{s}{u+\frac{1}{2}v}$ when s=the space in which the velocity v is added (columns 6 and 5), and u=the velocity at the commencement of the period (column 4).

The pressures in the 9th column are found by the formula $p=\frac{vw}{tg}$ when v=velocity added in time t, and w=·06 lb. the weight of the shot, g being 32, the force of gravity.

Those in the 10th column are found by using the formula

$$v=\sqrt{2g\frac{p-p^1}{\pi}}$$

as given by Charles Austin, Esq., C.E., for the velocity of gas issuing through an orifice; when p=pressure of gas on square foot, p^1 that of the atmosphere; π=weight of a cubic foot of gas.

$$v^2=2g\frac{p-p^1}{\pi}$$

neglecting p^1 as being accounted for in the next column, and assuming π=1 lb., we have $v^2=2gp$ ∴ $p=\frac{v^2}{2g}$= pressure per square foot. The pressure on $\frac{1}{3}$-inch $=\frac{p}{3\times144}=\frac{v^2}{26,208}$ lb. $=(\frac{1}{10}v)^2\times$ ·004.

The resistances in column 11 are obtained from Hutton's formula for spheres moving through the air, $R=\frac{(\cdot7565v^2-17\cdot5v)d^2}{10,000}$, d being the diameter of the sphere in inches. I assume the resistance in a confined space like the barrel of a gun, and the friction against the sides, at four times the above, in round numbers $\frac{12v^2-280v}{90,000}$ lb., and the numbers in column 11 give the mean between that at the beginning and end of the short periods.

The 12th column is the sum of all the three preceding, multiplied by 3 (the area of the section of the bullet being only $\frac{1}{3}$ square inch) and divided by 15.

The manner of obtaining the next three columns is evident.

NOTE D.

A gun could of course bear a greater strain near the breech than an open cylinder, on account of the metal closing the breech assisting what we may call the sides in opposing the pressure. A gun possesses another element of strength in the pressure not coming at once on the whole bore. Thus, during the infinitesimal period that the pressure is only on, say 12 inches from the breech, it is evident that also the 13th, 14th, and in a large cannon many more inches, assist in resisting the pressure.

NOTE E.

It may perhaps make this more evident if we consider the case of india-rubber. We found that a tube of this material 10 inches bore and 10 inches thick, when stretched till the diameter of the inside is doubled, diminishes in thickness from 10 to 7$\frac{1}{2}$ inches. (See figs. 2 and 3.)

Now if we attempt materially to strengthen this tube, by merely fitting another accurately over it, we must fail, because so little of the strain will be communicated to the outside, the inner diameter of which can at most be stretched from 30 inches (its original size) to 34$\frac{2}{7}$, the size of the outer diameter of the inner tube when stretched. Even this amount we should lessen, on account of the pressure on the inner tube, which would make it slightly thinner and longer.

If however we put a tube whose inner diameter is only 17$\frac{1}{2}$ inches over the inner one (for which purpose the former must be temporarily stretched, as the outer diameter of the inner tube is 30 inches), then both tubes will be nearly equally strained when the inner diameter of the inner tube is doubled, as the inner diameter of the outer tube will also be doubled, becoming 34$\frac{2}{7}$, having originally been but 17$\frac{1}{2}$.

Any number of layers of tubes can be made each to do a fair share of work, by regulating their original size, so that when the inner tube is extended to a certain amount, each shall be extended to the same amount. Should this amount be exceeded, however, the inside will again have an undue share of strain. On the other hand, a small strain will affect only the outer layer.

Digitized by Google

NOTE F.

Prof. Barlow's expression (1) for the strength of cylinders (Note A) $\frac{crx}{r+x}$ gives us $c \times \frac{4 \times 8}{12} = c \times \frac{32}{12}$ as the strength of an 8-inch gun with sides 8 inches thick, and $c \frac{6 \times 6}{12} = c \times \frac{36}{12}$ as that when the bore is increased to 12 inches;—the thickness being *diminished* from 8 to 6 inches, yet the strength increased. This is interesting, as it proves that hydraulic presses would be much stronger if cast thinner. Dr. Hart's formulæ give the same result, and experiment has confirmed it.

ON THE COMMON SENSE OF ART.*

By A. J. BERESFORD-HOPE, Esq., M.P.

THE lecturer said, he often found that what they might call the prose of art was handled with great ability, and at considerable length, by writers of various technical and scientific treatises. He also found some treatises on what they might describe as the poetry of art, the subject being treated in a more or less imaginative manner. But there was one phase of art which had never, by that term, been treated specifically. It was something that should seem superior to prose, and something that should seem superior to poetry,—that thing that was not so common, and which the French proverb said was by no means common,—he meant common sense. By "the Common Sense of Art" he hoped they would allow him to say, that he did not mean to imply that he wished to lay any particular claim to his own common sense upon the subject; but to give them some idea as to what, in his mind, constituted the common sense of art. And, if he were to define common sense, he should say it stood in an ascending ratio —that it was something beyond prose, and something above poetry. Prose, we were told, was the best language in which to describe any particular thing; poetry was the best language, having the best words in the best places; common sense was the best thing in the best place, and, therefore, above prose or poetry. With this preface or definition of common sense, he would, with their permission, at once plunge into the subject.

This being an Architectural Museum, they might ask why he called upon them to consider not merely the common sense of Architecture, but the common sense of Art. His answer was this,—that Architecture, whether it were an art that involved and included all others, was at all events the art that busied itself and was concerned with all others. Painting stood by itself, as did sculpture; painting required no assistance from sculpture, neither did sculpture require assistance from painting. But architecture, though it had an existence of its own,—though the doctrine that architecture was merely the machinery to convey ornamentation was one that he must denounce as a heresy,—architecture, he said, though an art of its own, was intimately blended with all other arts. Therefore, in looking at the common sense of architecture, they would see what was the common sense of all art, and they would have to consider all art in its relation to architecture. In laying down some canon of architectural common sense, what first principle should they start with? He believed that he should most safely start upon the broadest grounds,—upon the enunciation, which he ventured thus to make, that with all the varieties of style, with all the different conditions, with all the merits, and with all the demerits of different lands, yet, considered implicitly in itself, the object of all architecture was one and the same—the means by which to attain the end in view, however imperfectly that might be realised. What was architecture? It was the struggle of the human intellect to assimilate the great physical wants of man,—the want of man which he felt for covering,—covering for his daily life, covering for his public duties, covering for his religious observances, and to carry out and realise the great architectural ideas of beauty which existed in every human mind. That was the first of architecture, —that was architecture pure and simple,—the architecture, that was to say, of construction. But next to the architecture of construction, and treading closely on its heels, came the ornamentation of all construction. That ornamentation no longer referred itself directly to the archetypal idea,—indirectly no doubt it did so;—but directly, and in the first instance, it dealt with the glorified reproductions of the visible things of human nature,—the reproduction of crystallised organisation, the reproduction of vegetable life, the reproduction of animal existence, and, above all, the reproduction of that purest and noblest exemplification of beauty vouchsafed to us—the noble and Godlike image of the human form. Thus, with these various relations of ornamentation to painting and to sculpture, architecture did, as he said, concern them above and in all art, and therefore it ought to be considered in connexion with all that art.

Now, thus having made these prefaces, and realised to themselves that architecture was the study of the archetype, as he attempted to word it, where could they begin their progress?—Where could they, as pilgrims in this land of England in the year 1858, begin their journey?—where could they take their start in their voyage of discovery in search of the ideal?—where, to make use of a beautiful mediæval myth, could they look for the Temple of Sangraal, a building which was imagined to be the embodiment of all that was beautiful and hallowed in all the buildings of creation? Whence could they take their journey towards this ideal?—where could they find the clue that was to lead them up the thorny mountain-path that would bring them to the green valley that encircled in its woods the crystalline pool, where dwelt reflected in the waves the image of the temple built above?

> "——— Windless and crystalline pool,
> Where ever dwells in unerasing waves
> The image of the temple built above,
> Distinct with column, arch, and architrave,
> And palm-like capital far overwrought,
> And populous most with living imagery;
> Praxitelean shapes, whose marble smiles
> Fill the hush'd air with enchanting love.
> It is deserted now; but once it bore
> Thy name, Prometheus!"

Prometheus in learned tongue meant the man of forethought,—the man of common sense. Taking this common sense as their guide, where should they Englishmen, in this waning age, where should they work up for their idea, and where should they find a clue that would lead them to this temple? He said that for them, being Englishmen, being Teutons, being Europeans, being members of the great civilised and great Christian fraternity of nations,—a strong, a very strong antecedent probability was that they should find their starting point in their pilgrimage for a style of architecture in what should suit them as Englishmen, suit them as Teutons, suit them as Europeans, and a portion of the civilised and Christian fraternity of nations. He said there was a strong probability that in such an antecedent they should have a starting point to gain a style. He would base the rest of his discussion upon that probability. Of course, whether their search were successful, or whether it were not so, was not the point for them to set forth. What they had to do was to labour onwards, and to trust to events for success. It might be that art was waning in the land, and going to its fall; or it might be that art was rising to a noble future. But their task was one and the same. If the world of art was still in the diminutive morning of its growth, then let them toil for the bright and sublime noonday; if, on the contrary, it was drawing to its eventide, then let them anticipate a glorious sun-down. Then, with these prefaces, dwelling on this antecedent probability, where should they take their stand? Should that architecture of the future, to which they looked, be an architecture that was progressive, or should it be an architecture that was stationary? Upon this matter he would have to offer to them two reasons: the first reason was a positive one—that it ought to be progressive; the second reason was a negative one—that it could not be stationary. As to the first reason—that art ought to be progressive—he would not argue, for it was an argument which they must have heard thousands and thousands of times in lectures, in books, and in journals,—it was an argument that was drawn from our history and literary achievements, and from the fact that all art had been progressive in every age of the world. With that brief sketch he must leave his audience to fill up the outline upon that point. He must, however, speak more at length upon the second part,—why architecture could not be stationary. He would narrow the question by appealing to their own consideration as Englishmen, and to their own particular phase of art, to which he had directed their attention. He assumed as a certainty that their art for the future was to be founded on the Gothic. Well then, granting that, could their Gothic for the future be stationary? If so, it could not be stationary without standing somewhere? Where then should it stand? They knew there were the Gothic of England, the Gothic of France, the Gothic of the Low Countries, the Gothic of Italy, the Gothic of Spain, and the Gothic of Germany. And they knew that all these Gothics had an early and a late

* Lecture delivered at the Architectural Museum.

Digitized by Google

phase, and many of them a middle one. On which should they make their stand? He said the English stand-point must be somewhere within the Gothic of England. As to the stationary view of the matter, there could not be advancement, nor could there be retrogression,—advancement and retrogression were equally contradictory to the idea of being stationary. Well, Gothic, as they knew, after many centuries, was put to the bar of public opinion. It was thought that it had died, but it came to life again. But if it had come to life again it must be with its age upon it, like the statue-queen Hermione, with years of sorrow and exile on her brow. If architecture was to be stationary, it could not have advanced, neither could it have retrograded. By logic, which he defied any one to controvert, the stationary Gothic (if such there could be) must be the later and corrupted Tudor of Henry the Eighth in England; and in France it must be the Flamboyant of the House of Valois. But no stationary antiquarian would accept such a proposition; he would choose some style for himself of an antecedent date. Well, he said, that though he did carry out that style of an antecedent date with the most stationary accuracy, he did not for all that belong to the stationary school. Such a one was in short not stationary, but eclectic, and there was no such thing as a stationary school of Gothic. There might be an eclectic one; there must be a progressive one; and progress must select where it should progress. In short, the only theory of architecture which rested on common sense, which he set up as their supreme tribunal,—the only style of architecture for the future of England, was the Gothic architecture, cultivated progressively, and that progress founded upon eclecticism. But here they only got into their difficulties; if they were eclectic what had they to choose from? Where should they make their starting point? And, having made that, how far should they expand their diverging process, in bringing it to that centre which they should make for themselves? No doubt, whether they eclected in or out of our own land, their starting point must be within that land.

It would be in the recollection of many of those present that some fifteen or twenty years ago, when the new Gothic school first began to consolidate itself, a brisk controversy arose as to the development and perfecting of English Gothic. There was a strong party in favour of the Early English or First Pointed style; there was another party who were for the Decorated or Middle style; while there were a few outsiders who were in favour of the Norman, or the Perpendicular. After some time the victory declared itself in favour of the Middle or Decorated style, as the golden mean of English Gothic; for it seemed to be the apex of the triangle,—it seemed to be the holy ground from which they could survey the landscape around them. And so for some time they enjoyed that state,—they were in a state of insular pride—they believed themselves to be the best men in the world, and that nobody could beat their style. But very soon knocks were heard at the door from many a quarter; they found out, they learned, they realised at the bottom of their souls that there was such a thing as Foreign Gothic, that it was a noble and a multiform thing, and that it had many claims on their admiration. First of all came the Gothic of France,—of free France—with its unrivalled churches, and its enthusiastic band of eloquent young art-writers, headed by the young, intrepid, and noble-minded Montalembert. These buildings and these writers arrested our respect, and went far to divert us from the admiration of the Middle style to that stern and severe style which was the ideal of the Early French Gothic, and which had been impressed on their minds more recently in consequence of the Lille competition. Then came a voice from Germany, by several monuments in that country, all of which had claims on their attention,—in the completion of the Cathedral of Cologne, the rebuilding of St. Nicholas at Hamburg, and the Art-monument at Munich. The Low Countries, too, opened themselves to our investigation. Perhaps, a little later, English architects and tourists crossing the Alps found that they and their fathers had long been blind, and found that in the very plains of Italy, in the Campagna of Rome, there were to be found Gothic structures full of grace and beauty. These impressions were deepened by a sense of wrong, and thus they were led to recognise that Italy had also yielded its contributions to their first style. Here, then, was what he might say was the present attitude of what he might call the Gothic party in England. There was a strong feeling in favour of the various phases of the Middle style; another party, smaller and humbler, had supporters in favour of the Early style; and then there were supporters of the French or of the Italian specimens. How, then, were they to deal with these? and how were they to meet this difficulty? Was any English style in itself sufficient for our wants?—assuredly not. Was the French sufficient for their wants?—he would not say it was. Was the Italian?—certainly not. Were all these three collected and taken together sufficient,—the Early and Middle English, he meant, the French, and the Italian?—not even so. They must have something more broad and more comprehensive even than these for their starting point. They must have peace; but peace in this case could not be got by comprehensiveness. And if they were to have eclecticism, eclecticism must eclect out of everything that could be collected. The English school were very logical in choosing the Middle style of English architecture. They must do the same thing, and bring together for themselves some middle form out of the Gothic architecture in all and every age. In doing so they only did half the work that might be in store for their successors after them. That eclecticism of which he had spoken so often was the eclecticism of the past; there might be, and there would be, he imagined, an eclecticism of the future. That progress of manufactures which produced materials of singular beauty of colour, of singular durability, out of the earth; that literal fulfilment of the prophecy—that for stones we shall have iron; the increased means by which the vegetable and mineral productions of every land are laid at our feet,—all these might in time revolutionise architecture; but he thought it would be a pacific and not a destructive revolution, and that all the changes would not supplant, but only supplement the architectural traditions of the past. For himself he would only endeavour to grapple with the eclecticism of the past, and to contribute one stone to the structure of the eclecticism of the future.

Here then again to revert to first principles; they had to perform their task of progression through eclecticism, they had to eclect out of the past; they had to select out of the Gothic of their ancestors. All would agree that they must select from the past of France, from the past of Italy, and from the Early and from the Middle days of England. But were they to stop there?—was there nothing else to select from? He was going to refer to a selection that might seem to run counter to a great deal said by those of high authority in architectural matters in latter days. He said there was much they might select from in both the Later Gothic of England and of the Continent. It was easy to talk of the germs of corruption of the Later and Middle Gothic of the Flamboyant and of the Early of England. But easy as that might be, it was a truth that was only half a truth; for, distorted, perverted, and corrupted as the Gothic of that period might be, it yet unfolded vestiges of vitality destined under more favourable circumstances to be brought into life hereafter.

If there was one axiom more undeniable than another, it was that,—without attempting for one minute to strike the balance of merit between the two, but merely to make a naked statement of fact,—if there was one axiom more undeniable than another it was, that Classic architecture was the architecture of the horizontal line, and that Gothic or Pointed was the architecture of the vertical. And Classic was the architecture of superposition, while Gothic was the architecture of germination and continuity. Well, taking that—the germination and continuity of Gothic,—let them look at the Early English just emancipated out of Norman, and let them look at the Early French building. What did they see then? They saw a pillar surrounded by a capital with a very broad abacus, which in the French was absolutely square; they saw the mouldings very different in their sections from the shafts placed under them; they saw strings of horizontal lines of very dark shadow; they saw square lintels; they saw low-framed pediments; they saw strings of windows arranged in horizontal strips; they saw spires growing out of towers with strong horizontal indications, and pyramidical turrets at the corners,—they saw such indications, all of them strongly flavoured with the horizontal principle. They saw that the Early Gothic had inserted that horizontality which came from the Renaissance, which was drawn from Roman, and which was taken directly as a free gift from Ephesus and Athens. He did not deny that there was a great massiveness and beauty in horizontality. So, too, in the second style of Gothic. In the form in which tracery was put in, in the way in which windows and geometrical forms were put together, in the way in which circles and so on were put together, they saw something that a great deal more resembled superposition than it resembled continuity. Now change the scene, and come to the late Gothic. Take one of the Flamboyant cathedrals of the Low Countries; they saw there that

Digitized by Google

there was a great deal of perversity, a great deal of scrambling grotesqueness for effect, and a certain vulgarity of sentiment; yet they saw that under that vulgarity there were the germs of continuity, the differential characteristic of Gothic.

Having pointed out some of such indications as were manifested in Early Gothic, as shown in the Cathedral at Antwerp, and in specimens at the Crystal Palace, the lecturer proceeded to make some remarks in reference to the Flamboyant and Perpendicular. He said, that in their Gothic of the future, while they repudiated the shabbiness and feebleness of the Flamboyant and Perpendicular ornamentation, they must not deny that they were the first principles which they saw in ornamentation. When he saw the Flamboyant style he was reminded of the German tale of the giant, who was so weak that a child might throw him down, but whose shadow was so strong as to knock down trees and men;—or he was reminded of a story he once read in a foolish railway story-book, of an artist who wooed and won a lady, and under her face discovered the distorted lineaments of another face which she ought to have had, but did not have. The later phase of English Middle Pointed, the flowing Decorated, had never had justice done to it; it carried its death-warrant with it from the first; in spite of its beauty the hectic flush of dissolution was along with it. The students of Rickman were well acquainted with that. Here, then, were some arguments, he said, for which he might dare to challenge contradiction,—that the Later as well as the Earlier styles of the Gothic of England, as well as of the Continent, shall contribute to future eclectic art. But he might be met by the argument on the other side,—that this Early Gothic of England (especially the Early Gothic after it had emancipated itself of Romanesque) and that the Early Gothic of France, were pre-eminently masculine. He fully granted that, and confessed that he pitied the soul of the man who could step for the first time under the choir of Shoreham or Canterbury, or other of the buildings of that period, without feelings of emotion and admiration. This style was overpowering,—it was noble, it was masculine. But, while they gave it the praise of being masculine, did they give it all praise? Was all the world masculine? Were there not graces which were attributable to the other half of creation?—Norman and Early Pointed architecture, which were the mirror as it were, shadowed out only half of that creation. To have done so might be a great thing for their forefathers to have accomplished; but they, the disciples of common sense, the advocates of eclecticism through progression, scorned to be contented with half measures. Nature was great and varied; and, while he recommended them to avoid luxuriance of ornamentation, he would also recommend them to take care that they did not fall into the opposite extreme of stiffness and angularity. They might admire the purity and grace of the semicircle and the lancet; but in nature they were rare forms; while they would find multitudinous in nature, the beautiful form of the ogee. Honour, then, to the man who introduced that ogee into architecture,—who first enlisted it in the troop of the servitors of architectural glory! It had been toyed and dallied with until it had been weakened and deprived of much of its beauty; but, in its proper place, and in due subordination, as it was to be found in the Archway at Bury St. Edmund's, it might be regarded as a splendid contribution to the resources of architecture. And the ogee was only of the Later style of architecture. He said, then, that they should take up the Early and Late styles of English Gothic as well as that of the Continent.

They knew that the progress of modern discovery had yielded to them great advantages in ornamentation,—such as the serpentine, the red and white granite of Scotland, and the many accessories to art afforded by the Staffordshire kilns. As to the Italian, surface colour and ornamentation were to be found more in the Italian than in other Gothic. In street architecture, too, we had a lesson from the Italian; the system of street architecture followed called for a cornice where our ancestors would have put up a gateway. And so, he said, that the Italian Gothic ought to yield its share in the construction of their eclectic and progressive style of the future. If they held fast to these principles, and if they gave to their architecture of the future the distinctive characteristics of each style,—making it masculine as the Early French, and effeminate as the Flamboyant, as they might wish to make it so,—what a boundless field of imagination opened itself before them! For instance, they might want a building in which should be given to the lower story a rustication; the lower story should be of the Early style, and the upper stories should be of the continuous. Or they might wish to produce the artistic effect of the overhanging cornice; then they would borrow that from an early date. Again, the windows, instead of being ranged in horizontal arcades, might assume the vertical strip, with columns, instead of the flimsy mullions of the later days. Let them have sometimes mullions, sometimes pillars,—everything just where it was wanted. Even as to the latest manifestations of circular windows of Henry VII.'s time, why should not these be pressed into their service as they became wanted? But it might be asked, "Where will you stop,—what is there you will not absorb?" To this he would answer, that he would stop where common sense told him to stop, and that he would not absorb anything that common sense forbade him to absorb. But onward he would go, until common sense checked him; he would take all on which common sense had not laid its brand. He would ask the architects of the future to employ the Renaissance; and he did not see why the stout-hearted men of the future should not appropriate and make their own the treasures they might find in the palaces of Rome, of Athens, and of Florence.

So much for architecture; but, as he had promised to speak of the Common Sense of Art, he would now address himself very briefly to the common sense both of Painting and Sculpture. In painting they must all acknowledge—however much we might like to see some particular phases of practical art,—they must acknowledge that the broad distinction between what was Classical and what was Gothic in architecture did not exist in painting. There were painters whose Christian tone delighted us, and there were others whose Pagan tone pleased us; but, generally speaking, there was not that thorough distiction in painting which was found in architecture. Therefore, in painting, common sense taught them that eclecticism might be more easily accomplished; there were less surface difficulties in making good its claim than they would find in the sister, or rather the mother art of architecture. He honoured those men who wished to strike out for themselves a new school,—who looked to purity, and relied upon tradition and nature for the canons of their art; but he could not honour the study of rudeness for rudeness' own sake. He agreed, then, thoroughly in repudiating with disgust the vulgar, the trite common-places of academic models; he repudiated academic models, because their beauty, if beauty they had, was of the vulgar and of the inferior sort. But their beauty being of the vulgar and inferior sort, the best protest against it was not to represent with startling accuracy the vulgar, but to raise the standard of an ideal beauty. No doubt second and third rate painters had been neglectful of their outlines, and atmospheric effects were juggled in a manner wholly at variance with the designs of the Great Architect of the Universe. The same Creator who made the mountains and the fields made also the air and the mist, and never intended that all nature should appear without atmosphere and under the bright noonday sun, or that it should have a literal dry distinctness. They must not be led away by new school doctrines any more than by old; they must look at the matter in a common sense view. If they took a mythical subject, or a scriptural subject, they must try to be not too vulgar, but to be ideal. And if they wish to be real, they must imitate nature. In painting nature in her various aspects artists should take care not to be deluded by a longing after effects that were irreconcilable with common sense. For that reason, he confessed, he did not wish to see leaves and flowers appear in pictures with the literal dry distinctness which some people admire, and which could only be seen by persons who, unlike himself, were not short-sighted.

It would be found that artists who were the most literal, not only in mass, but in every line and fold, were not always the most pleasing. Amongst the most literal of the Dutch school might be named Vanderveldt; and in the English school the clever caricaturist, our over-praised Hogarth, whose works, however, he should not set up as models. Such was not the mode in which our fathers worked, or in which Praxilites worked, or the method adopted by the men who sculptured the figures at Wells or Chartres; and such a mode of working would have been repudiated by the time-honoured Flaxman. Whatever defects, however, there might be in art, there was, he believed, in our painting and sculpture of later years a spirit of reality such as we never knew before, and that showed that they were on an onward march. And so it was in architecture; how long it might be on that march they could not tell. They knew that perfection in this nether world was, of all things, most uncertain. They knew that the brightest flowers were the first that faded, and the noblest aspirations were often nipped into despair, or soured

Digitized by Google

into cynicism. But it was not for them to indulge in such a thought. Let them, then, toil and labour on in search of truth, in search of progress, in search of the ideal, in search of common sense, as if on each of them singly depended this ideal of success. And then the crown, the satisfaction would be all the more most legitimate, whatever the broad result might be. For to toil, suffer, and labour for the truth, and, if need be, to die for the truth, was the Common Sense not only of art, but of all human life.

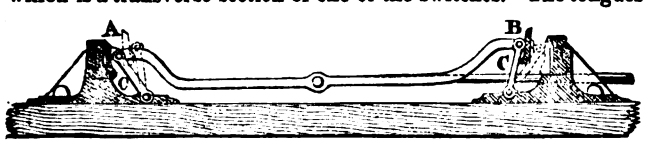
IMPROVED RAILWAY SWITCH.*

By J. A. Haswell.

In the various kinds of switches now used on railways the moving tongue slides upon the chairs, rubbing upon them throughout the extent of its motion; and the switches are made self-acting by a balance weight hanging from the lever and constantly pressing the tongue home to the side of the main rail. But in practice this plan is found defective; for, although a weight is employed as heavy as can be conveniently worked, its action is uncertain, being frequently impeded by the friction of the sliding tongue from the chairs having become dry or the oil becoming adhesive or mixed with sand and ashes; the tongue rails are then liable to remain on the wrong side, or only partially reversed, thus presenting both tongues open, and causing danger of accident from wheels running off the rails by the flanges entering between the tongues and main rails at both sides. To lessen this defect a raised strip has been used upon the rubbing part of the chairs, which reduces the surface for holding sand; but this plan involves the objection of the oil being sooner rubbed off by the motion of the tongue from the increased pressure between the rubbing surfaces. The large consumption of oil that takes place with the ordinary switches forms a serious item of expense, most of the oil that is applied being unavoidably wasted.

The new construction of switches described in the following paper, which is invented by Mr. Edwin Thompson and Mr. William Nicholson, of York, is designed to remove this difficulty by avoiding the sliding of the tongue-rails upon the chairs, and so dispensing entirely with the use of lubrication.

The construction of these switches is shown in the annexed, which is a transverse section of one of the switches. The tongues



A B are of the ordinary form, but a short iron strut or link CC is jointed to the thin end of each tongue-rail and to the end chair, so that when the tongue-rail is opening this strut causes the end of the tongue to rise off the chairs, and the other tongue at the same time descends upon the chairs, the short strut acting as a radius link. The elevation of the tongue-rail when open is 2 inches above the level of the main rails, which is found to ensure the tongue-rail being properly put down upon the chairs and closed to the main rail, and being also entirely clear from any low portions of the engines, &c.

In this construction of switches, on account of the sliding motion and friction of the tongue-rails being entirely avoided, oil is not required, and no danger can arise from sand or ashes lodging on the chairs: also the removal of any larger fragments of coke or ballast is to a certain extent provided for by the altered form of the chairs, which this manner of opening the tongue-rails admits of. As the tongue-rails require no larger surface to rest upon than is actually in contact with the chairs when they are closed to the main rail, advantage is taken of this by increasing the thickness of the chairs at the particular part upon which the rails rest, forming a raised step which is completely covered when the tongue-rail is closed; and on the open side the width of the tongue-rail only is exposed to the reception of rubbish, the larger pieces thus falling off and the smaller ones being crushed or removed by the descent of the tongue. The accomplishment of this object has been satisfactorily shown by the working of one of these switches, which has been put down in a situation where sand was constantly used for the engine wheels, and has continued to work well although sometimes nearly buried by the accumulation of sand.

In these switches the ends of the tongue-rails are extended a foot beyond the sharp edge that fits against the top of the main rail, and the extended ends are curved inwards like a check rail end, and reduced in height 1¼ inch to allow the wheel flanges to pass over the top when the tongue-rail is closed to the main rail; and in any case of the tongue not being properly closed the pressure of the wheel flange will tend to crush any obstructing substance upon the chairs. This action is aided by the check-rail end of the tongue on the opposite side, which in such a case will not be opened to the full extent but sufficiently so to guide the wheel flanges in the proper course, and by drawing them from the other imperfectly closed side prevent the wheels from taking both lines.

The advantages aimed at in these switches are safety and economy in use, on account of their working as well without oil as the ordinary ones do when clean and perfectly oiled, saving by this means a cost of at least 20*s.* per annum for each switch; the safety from risk of the switches being reversed when the train is passing over, either by a bent axle or other unusual strain, in consequence of the closed point being kept down by the weight of the train itself; and the convenience of these switches for shunting, for which no balance weight is required, the tongues being perfectly safe when standing on either side, thus requiring less attention from the men engaged with the trains. The application of this plan does not require any alteration in the dimensions or form of the ordinary switches in general use, and it can be applied easily and at trifling cost to those already fixed and in use.

Some of these switches are now in constant use at the York and Newcastle stations, where they can be seen in operation.

In the discussion which followed, Mr. J. Bourne said that he had had one of the switches in operation at the Newcastle station for a month, and some others had been tried for about six months at the York station; these had been working very satisfactorily, and were found to have a decided advantage over the other switches in use. The others required constant oiling and attention to keep them in working order, and the oil collecting the dust and grit caused frequent cleaning to be necessary to prevent risk of accident from the switch sticking partly open. In winter great difficulty was experienced with ordinary switches from the snow, which partially melted in the day-time and then froze again in the evening, causing the switch tongue to be choked up by ice and prevented from shutting close, and the men had to be continually using salt to thaw the ice and keep the switches working. But these new switches were completely free from those defects, and appeared very successful in meeting the requirements of self-acting switches; no oil was used, and this effected an important saving in annual expense; and from the switch tongues not having any sliding motion on the chairs no inconvenience was experienced from sand and dust, and the risk of their sticking partly open was effectually prevented, as they must fall on one side or the other. In reply to a question,—whether any special provision was required in boxing up the switches to protect them from injury, Mr. Bourne said that the switches were all boxed up in the station yards to protect the connecting rods from the risk of being caught by the waggon coupling-hooks; no other protection had been required for the new switches, and they had kept in complete order.

In reply to an inquiry, whether an engine passing over the switch backwards opened the tongue as readily as in the ordinary switches, Mr. J. A. Haswell replied that no difficulty was found in this respect, and the small-sized chaldron coal-waggon readily opened the tongues.

Mr. E. A. Cowper thought the new switch accomplished in a very neat and effective manner an object that had been much aimed at, and had been the subject of many ingenious schemes. One plan that had been proposed was to have inclined surfaces upon the chairs for the switch tongue to slide down; but there was an objection to an inclined plane in the risk of bending the tongue from the friction when the weight came upon it; and it was undoubtedly a favourable point if the use of oil and the sliding motion could be entirely dispensed with, as in the plan now described. The new switch would have a tendency to crush

* Paper read at the Institution of Mechanical Engineers.

Digitized by Google

any stones by dropping down upon them in closing, and it would certainly be less likely that anything would remain on the chairs than in the case of the ordinary switches, where the action in removing stones was by pushing them along, and there was the risk of some getting jammed in between the tongue and the main rail, and preventing the tongue from fully closing.

Mr. J. Tomlinson remarked cases were frequent of engines getting off the rails from a switch remaining half open, so that both tongues caught the wheel flanges; and thought it would be a useful improvement if this switch prevented the risk of sticking half open, by the tongues being sure to fall on one side or the other.

THE PEEL INSTITUTION, ACCRINGTON.

The new building for this institution was opened on the 24th December last. It is built in the Modern Italian style, the principal front having a bold projecting arcade under cover of which carriages can put down or take up for the principal entrance. The arcade has deeply recessed and moulded semicircular arches with rusticated quoins and voussoirs; the central archway having a finely executed head of Minerva on the keystone. The arcade forms the base of a portico of ten Corinthian columns, surmounted by medallion cornice and pediment. The wings are lighted by windows on the ground story, having rusticated arches and quoins, and on the second story by handsome moulded windows having carved trusses and segmental cornices; the whole being surmounted by a bold cornice and balustrade.

The ground story is approached by a spacious entrance hall, 24 feet square, from which is the principal staircase to the second story. It also comprises rooms for the accommodation of the mechanics' institution, consisting of reading room 32 by 25 feet, class rooms, &c.; a meeting room 45 by 26 feet, and other rooms intended to be used as town's offices, &c. The second or principal story is devoted entirely to a large public hall or assembly room, 120 feet long, 45 feet wide, and 30 feet high, having ante and retiring rooms, with gallery over.

The interior decorations of the assembly room are of considerable richness, and fully carry out the style of the exterior. The walls have panelled pilasters, filled in with festoons and wreaths of fruits and flowers, from which spring brackets for side gaslights; a bold medallion cornice and enriched frieze runs round the entire room, from which springs a coved and panelled ceiling, having the central panel enriched with highly decorative perforated flowers. The room is lighted by three handsome bronzed chandeliers, supplied by Massinger, of Birmingham, and is ventilated through the ceiling and roof. The entire building is heated by Hadens' system of hot air and water combined, and is very effectual in its operation. The entire cost of the building, exclusive of land, will be when completed about 9000*l*.

The architect from whose designs and under whose superintendence the building has been erected is Mr. J. Green, Portsmouth-house, Todmorden.

EXHIBITION OF THE PHOTOGRAPHIC SOCIETY, SUFFOLK STREET, PALL MALL.

On a careful examination of the pictures on view in this the sixth year of the existence of the above institution, we are disposed, while acknowledging the rapid strides which the art has made, to believe that some of its happiest productions, and those which tend most to exemplify its capabilities, will be found wanting on the walls. Consequently, although the collection is a large one, and possesses attractions of varied interest, that peculiar element seems lacking which would enable us to pronounce the present exhibition to be not merely superior in the number of meritorious works to any of its predecessors, but as illustrating one or more of every phase of application which photography has assumed. It is to be regretted also that so many duplicates have been admitted; we do not mean such as show a study in its crude and then in a coloured state, but *bonâ fide* reproductions in different frames; and this is more especially observable among the portraits, a class which, as in exhibitions generally, constitutes a prominent feature here. In the catalogue we read interminable records of "portrait of a lady," or "of a gentleman," which, under those titles, have not the slightest interest for the public; but some of these, again, meet our eye in which the vagueness of description has vanished, and the real name of the individual more properly takes its place. There are few things more truly interesting to a reflective mind than a leisurely comparison of what phrenologists call the "developments" of the heads of different individuals, and this interest is vastly heightened if one is enabled to identify well-known features, and to feel assured that every lineament we behold has been depicted with truth's unerring hand. By all means, therefore, if a revision of the catalogue should be called for, let the shortcomings of the present one be as far as possible made good.

The collection this year is a large one, numbering 643 subjects, but many of them having become previously familiar through the medium of the print-shops, such will not invite, in a general way, a renewed inspection. We allude to this for the purpose of suggesting whether, with such means of forming an annual exhibition as they ought to possess at command, the Photographic Society should not confine its selection (except in very special cases) to entirely new or unpublished works. The field of art now embraced is emphatically an ample one, and hosts of skilful practitioners are contributing the fruits of their labours from every portion of the globe. One most valuable series of photographs in the present gallery is that forwarded from Egypt by Mr. F. Frith, whose "Panorama of Cairo" (553), on a most extensive scale, is alone worth a visit to see. Such curious forms, yet elegant in combination, as are offered in Mr. Frith's views of "Mosques in Cairo," and "Tombs of the Mameluke Kings," are eminently suggestive to our adventurous architects, while to those who are attracted by the grandeur of nature, such views as his "Mount Serbal, Sinai" (547), and "the Sphinx" (549), "the Pyramids" (548, 551), and "Jerusalem" (558), will not pass unnoticed.

By far the largest wall space, however, is occupied by the wonderful reproductions of Raphael's Cartoons, by Messrs. Caldesi and Montechi, the most recent and one of the most useful achievements in the art. These photographs are of the largest available size, and must necessarily supplant even the most elaborate hand-transcripts of the masterly originals. Parts at large of each have also been taken as additional studies for artists, by whom they will be prized as a long-coveted treasure.

The names of Roger Fenton and Francis Bedford hold a prominent place in the catalogue, but not more so than their productions deserve. In every case we discern the operations of science commingled with the fascinations of artistic power. Mr. Fenton has done noble service to architects in his exquisite series of studies from our venerable cathedrals; nor, perhaps, are Mr. Bedford's contributions from our ruined castles and abbeys less valuable, as certainly they are not less picturesque and attractive. Those of our readers who have scanned the neighbouring "Architectural Photographic Exhibition" will have noticed the beautiful series of views from Tintern, Raglan, Chepstow, &c., which the latter gentleman has produced: some of these are again visible in the collection we are now surveying, while the additional photographs before us, which are of the same choice kind, may be said almost to have left no peep unexplored, or delicate fragment not brought to view. Mr. Bedford has also nine delightful views (108) of Gotha and its vicinity, photographed by command of Her Majesty the Queen; and, in conjunction with Mr. Cundall, (125) some pretty glimpses of Hever Castle, the Moat at Ightham, Charlton, Kent, and part of Rochester Cathedral. Nearly all of the photographs we have alluded to were produced by the collodion process. Others may be seen in which the collodio-albumen has been employed, while again for others we are indebted to waxed and plain paper, oxymel, the original Talbotype, and Taupenot's process. The cartoons are wholly by collodion. Two subjects (592, 613) have been worked by the "honey" process; and one, (603)—a photograph from an oil painting—has been transferred by photo-galvanography.

To the visitor who desires more closely to investigate the results of these several methods we would recommend for study, as among the gems of the exhibition, besides those already named, Mr. Edwards' "Study of Clouds" (4),—Mr. Morgan's "Study in Hambrook Glen" (15)—a charming specimen;—Mr. Fenton's "Views at Haddon Hall" (33, 61)—that favorite haunt of all artists;—the magnificent scene in "Dovedale Lower Valley" (51), by the same gentleman, and the stately majesty of his "Cheddar Cliffs" (55);—Mr. F. G. Eliot's four views from the lakes of Cumberland (89);—the splendid large photograph, by Mr. Philip H. Delamotte (169), of the "Crystal Palace, Sydenham"

Digitized by Google

(interior);—and the series of pictures, from (384) to (392), by Mr. C. J. Burnet, exhibited to show chemical actions. (See *Photographic Journal*, Jan. 21, 1858.)

Those who may be interested in architectural pursuits will find an agreeable, if not an extensive variety. The works of Fenton and Bedford already alluded to are by far the most finished and perfect of their kind, nor ought we to forget the views of Eltham, Penshurst Castle, Hever Castle, &c. in (580, 585), with which Mr. Cundall's name is also associated. Besides these we have "Sparrow's Ancient House, Ipswich" (72), by Mr. Dixon Piper;—a last century Roadside Inn, at Wansford, Northamptonshire (92), by Cundall and Downes, which has a truly sensible and comfortable look;—some clever studies, chiefly in Kent, by Mr. Cruttenden, such as (97), "the Baptistery, Canterbury Cathedral,"—and the "Christ Church Gate," near the same spot (110),—High Street, Maidstone (567),—"Boughton Monchelsea Church" (593)—a beautiful specimen; and Viscount Falmouth's seat at Mereworth Castle (631). There are several continental subjects which are exclusively architectural and good, such as those from the Palais de Justice, Rouen (178), by Mr. Howlett,—the "Porch at Rheims Cathedral" (271),—"Ruins of Heidelberg Castle" (485, 486), by Mr. G. C. Backes, &c. &c.; while, among English ruins, may be seen views of St. Osyth's Priory, Essex,—St. Botolph's Priory, Colchester,—and the picturesque remains of Walberswick Church, Suffolk (507), by Mr. Cade, who also exhibits a number of views of the Colleges in Cambridge.

THE BAROMETER AS AN ENGINEERING INSTRUMENT.

By JOHN M. RICHARDSON.*

(*Concluded from p.* 14.)

THUS far the results given by the level have been regarded as absolutely correct, and those obtained by the barometer as subject to error. But, after the comparisons which have been made, the question very naturally arises,—Which instrument gives the most reliable results? The question cannot be decidedly answered at present. Theoretically both the instruments give correct results, but each is subject to numerous errors. The chief sources of error in the case of the level are: (1) construction; (2) adjustment; (3) observation; (4) refraction; (5) dewpoint, as affecting refraction; (6) unequal expansion and contraction of the parts of the instrument; (7) curvature of the earth.

The errors arising from (1), (2), and (3) can be reduced to their minimum by careful selection, adjustment, and observation; those arising from (4), (5), and (6) cannot perhaps in practice be avoided; that produced by (7) can be partially corrected. The principal causes of error in the use of the barometer are eight, viz:—(1) construction; (2) adjustment; (3) observation; (4) dew-point, as affecting pressure of atmosphere; (5) unequal expansion and contraction of parts of instrument; (6) changes of temperature, as affecting pressure of atmosphere; (7) agitation of the upper strata of the atmosphere, currents, &c.; (8) daily variation.

Errors arising from (1), (2), and (3), as in the case of the level, can be reduced to their minimum by careful selection, adjustment, and observation; those arising from most of the others can be corrected, but they are usually small; and regarding the barometer as an engineering instrument, they would not perhaps be corrected, except the one due to changes of temperature.

The adjustment of the level is a complex and tedious operation, and requires so much time that it cannot be done before every observation. Hence an error of adjustment may exist for some time before it is discovered. The adjustment of the mercurial barometer is simple, requires but a moment, and has to be made before each observation. The liability to error of adjustment in the case of the barometer is not so great, then, as in the case of the level; but an error of adjustment of the former, although small, will probably cause a much greater error in the determination of differences of altitude than an error of adjustment of the latter.

An error of observation with the level will usually vary the result but little; but, as a very small change in the height of the mercurial column corresponds to a considerable difference of level, a slight error of observation with the barometer may introduce a very material error in the final result. Upon the whole, then, taking into consideration the other errors, as well as those to which allusion has been particularly made, the liability to error on the part of the level appers to be less than on the part of the barometer. Everything, however, will depend upon the care and skill of the observer; care in avoiding errors, and skill in eliminating those which cannot be avoided.

From this view of the relative liability to error on the part of the two instruments, and the examination of observations made with them, it follows, that although the level is probably the most correct, yet the barometer, when carefully used, will be a valuable auxiliary to the engineering profession.

It is to be hoped, however, that more comparative observations will be made with the two instruments; and it is respectfully suggested to scientific gentlemen who may visit Black Mountain, or who may have opportunity to do so at any other mountain, to run carefully a line of levels from the foot to the summit, driving a stake at every station corresponding to a change of level of 50 or 100 feet, and at every station so determined, to make careful barometric observations. The results thus obtained would probably be of great value, and would determine whether or not the barometer-differences of altitude are too great within certain limits, and too small within others. Some of the results of the observations quoted from the report of Lieut. Williamson appear to indicate the possibility of this being the case; if it is, and extended observations can alone determine it, the limits between which the barometer-altitudes are too great or too small can and should be determined. This subject will be dismissed after making some general observations upon the method of conducting a barometric survey.

According to Biot and others, in order to determine the difference of level of two stations by means of the barometer, simultaneous observations should be made at them: but this does not appear to be strictly necessary; for, besides the trouble and expense of having two sets of instruments and two observers, if the stations are sufficiently near for the same atmospheric conditions to prevail at them, they will hardly change during the time required for an observer to record his observations at one and pass to the other. If the stations are too far apart for the same atmospheric conditions to prevail at them, it is evidently unnecessary for the observations to be simultaneous.

How far north and south, east and west, do the same atmospheric conditions prevail? Has observation determined it? It is believed not. Here is a fruitful and valuable field for investigation. If two stations are separated by a considerable distance, and particularly if rivers, swamps, forests, chains of hills, or mountains intervene, it appears to be very improbable that the same atmospheric conditions, temperature, amount of moisture, clouds, winds, &c. &c., should prevail at them; and in order to apply the correction for horary variation it is only necessary to know the time of each observation.

In making a survey, however, it will be best to compare only those observations which have been made under pretty much the same atmospheric conditions. Thus, although it might do to compare together those observations made on a cloudy or a windy, or a fair and still day, it would not do so well perhaps to compare those made on a cloudy day with those on a fair day; or those made on a windy day with those on a still day, &c. Hence, having concluded the survey for one day, the survey for the next day should commence at the last station of the previous day's survey. Connecting the different days' work together in this manner, the final result, or difference of level of the two extremities, as determined by this chain of observations, should agree essentially with the result obtained by comparing together the independent observations made at the two extremities. Thus the barometer furnishes a check upon the observations made with it at intermediate stations.

It is advisable that barometrical surveys should be made during fair and calm days only; and, as the observations require but little time comparatively, and as they need be taken only where there are considerable changes of level, an engineer can so select his time as to execute the survey in good weather.

Travellers usually employ the "Mountain Barometer" (mercurial) for the determination of the altitudes of mountains, and for engineering purposes it is perhaps the best also. But the "Aneroid" is so portable and convenient, and requires such little time for making observations, that on these accounts it is preferable to the mercurial. The difference between the two is at most but little, and the aneroid is constantly approaching nearer

* From the 'Journal of the Franklin Institute.'

Digitized by Google

and nearer to perfection. As bearing upon the relative accuracy of the mercurial and aneroid barometers, the following mean result of fifty-six comparative and simultaneous observations made upon them by Belville, of the Royal Observatory, Greenwich, is given:—mercurial 29·61, aneroid 29·59. Twenty of the observations agreed exactly. The greatest difference was ·03, and it occurred only three times.

Formulæ and Tables.

I.—*From Williams's 'Practical Geodesy.'*

Let h=difference of level of two stations; M and m the barometer readings at lower and upper stations; T and T′ attached, and t and t' detached, thermometer at lower and upper stations. Then

$$h=68{\cdot}965517\,[8C6+t+t']\,[\log.\mathrm{M}+\log.(9600-\mathrm{T}+\mathrm{T}')-\log.m-3{\cdot}982271] \quad \ldots \quad \ldots \quad (14)$$

Example:

Barometers.	Thermometers. Attached.	Detached.
M=29·98	T=63°	t=62 lower station
m=26·17	T′=47	t'=45 upper „

Substituting in (14),

$$\left.\begin{aligned} h&=68{\cdot}965517\,[806+107]\,[\log.29{\cdot}98+\log.9584-\log.26{\cdot}17-3{\cdot}982271];\\ &=68{\cdot}965517\times 913\times[1{\cdot}476832+3{\cdot}981547-1{\cdot}417804-3{\cdot}982271];\\ &=68{\cdot}965517\times 913\times 0{\cdot}58304=3671{\cdot}1415; \end{aligned}\right\} \quad (15)$$

II.—*From Belville's 'Manual of the Mercurial and Aneroid Barometers.'*

Let h = difference of level of two stations; A the mean height of the barometers in inches; a their difference; b the number in the following table corresponding to the mean height of the thermometers. Then

$$h=\frac{30ab}{\mathrm{A}} \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

(16) is the formula of Sir George Shuckburgh: it is empirical, and gives results rather greater than those of (14); but the experiments of Sir George are regarded as being very exact.

For the aneroid Belville gives this formula,—As the sum of the readings : their difference :: 55,000 : the difference of level.

Let h=difference of level of two stations; M and m the readings of the barometer at them. Then

$$h=55{,}000\,(\mathrm{M}-m)\,(\mathrm{M}+m)^{-1} \quad \ldots \quad \ldots \quad (17)$$

The results of (17) correspond pretty well with those of (16).

III.—*From Boye's 'Pneumatics.'*

Adopting the same notation as in (14), and representing by L the latitude of the place,

$$h=h'+h''-h'''+h'''' \quad \ldots \quad \ldots \quad (18)$$

$$\left.\begin{aligned} h'&=\left[\log.\left(\mathrm{M}\,[1+0{\cdot}0001001(32^\circ-\mathrm{T})-0{\cdot}0000104(62^\circ-\mathrm{T})]\right)\right.\\ &\quad\left.-\log.\left(m[1+0{\cdot}0001001(32^\circ-\mathrm{T}')-0{\cdot}0000104(62^\circ-\mathrm{T}')]\right)\right]\\ &\quad+60158{\cdot}5;\\ h''&=0{\cdot}00111\,(t+t'-64)h';\\ h'''&=0{\cdot}0028371\cos.(180^\circ-2\mathrm{L})\,(h'+h'');\\ h''''&=\frac{h'+h''-h'''+52252}{20886861}(h'+h''-h''');\end{aligned}\right\} \quad (19)$$

(18) is the most correct formula (theoretically) of the four which have been given. It takes into consideration nearly all of the errors which can be corrected in the calculation. For extreme theoretical accuracy, M and m should also be corrected for *horary variation*.

In applying (18) care must be taken to give to h'', h''', and h'''' their essential algebraical signs. h'' is usually positive, and varies from ·03 to ·06 of h'. The essential sign of h''' will depend upon the value of L. If L is less than 45°, cos.(180°−2L) will be negative; and the term, $-h'''$ will become $+h''''$. h'''' is always positive. If the latitudes of the stations differ, L may be taken as their mean. h''' and h'''' are usually so small that they may be omitted when only ordinary accuracy is necessary. Neglecting them, (18) becomes,

$$h=h+h'' \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

The values of h' and h'' are obtained from equations (19).

The formula by which the results in the 'Report' were obtained is not given. This is a grave oversight on the part of Lieut. Williamson, or his computation. The principal reason for instituting the comparison between the two instruments was to determine their relative accuracy; and it is not sufficient to give merely the results of the computations; processes and formulæ should be given in full. Different investigators have deduced different formulæ, and these do not give the same results. In instituting a comparison between the two instruments the particular formula used in the computations should be given, for any other will not probably give the same results. For engineering purposes the formula should be as simple as possible.

For more particular information with regard to the philosophy of the barometer, its construction, &c., the reader is referred to Boye's 'Pneumatics,' Belville's 'Manual,' and Williams's 'Geodesy.'

NEW CHAPEL, ROYAL DOCKYARD, WOOLWICH.

(With an Engraving.)

This building being now in all respects completed, we are enabled to give a perspective view of the exterior from the north-east. The site is close to the entrance to the Dockyard, and altogether a favourable one for displaying the features of the design from several points of view. The west-end faces a large open square, and is consequently treated boldly in its character, but we prefer the effect from the position we have chosen, as it embraces most of the leading parts, including the bell turret and the chancel apse complete.

Having in December last described at length the particulars of this erection, it is only necessary to refer our readers to the number for that month for such further information as may interest them.

ON THE GREEK CANON OF THE PROPORTIONS OF THE HUMAN FIGURE, QUOTED BY VITRUVIUS.

By Joseph Bonomi.*

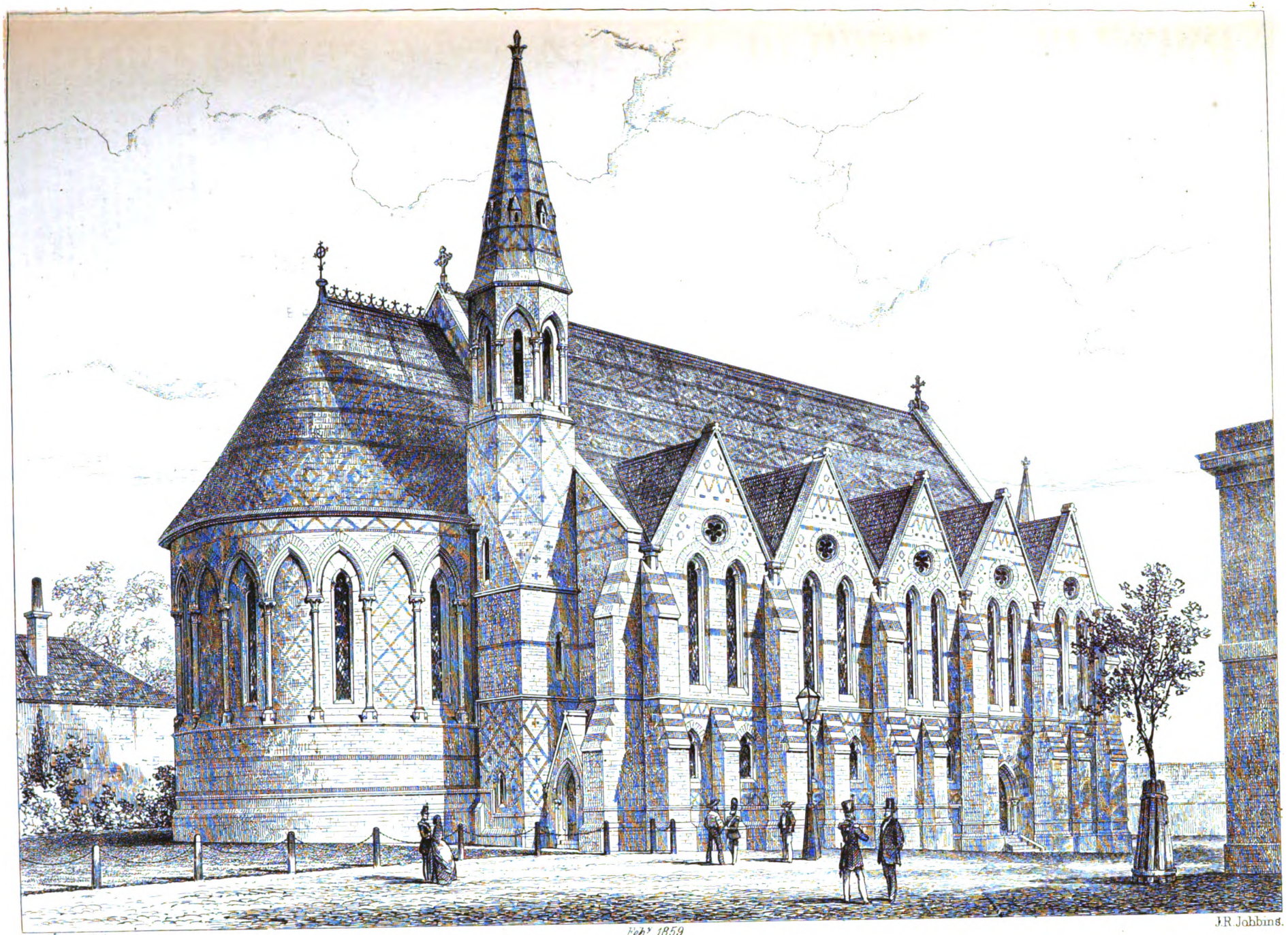
It has been remarked, that although all nature bears the impress of law, to men in general she presents only a number of detached phenomena. To the diligent inquirer alone, or to those whose mental vision is acute enough to have discovered some link in the secret chain of her laws, does she gradually unfold all the relation which these phenomena bear to each other. Thus the laws which govern the analogy or proportion which the several parts of the human structure bear to each other, although very anciently sought, were probably not entirely discovered or entirely recorded till sixty years or more after the birth of Phidias, at which time Polycletus, a famous sculptor of antiquity, made a statue so exact in all its proportions, that it was considerd the most perfect model of a full-grown man. This statue furnished the canon or law of the proportions of the human figure, which from that period is said to have been observed by all the sculptors of antiquity.

Part of a canon or record of the proportions of the human figure is preserved in the second chapter of the Third Book of the Treatise on Architecture by Vitruvius, in which book that learned architect treats of the proportion, or analogy, which the several parts of an architectural structure should bear to each other, and enforces his argument by a reference to the human frame, in which he tells us certain affinities exist, which were always observed by the most celebrated of the ancient painters and sculptors. This part of the Treatise is obviously a quotation, probably from the writings of the ancient sculptors or painters then in existence, and most probably from the canon of Polycletus.

I will now proceed to read this part of the Third Book in the translation by Prof. Wilkins, notifying certain variations in an Italian version of the same text by Leonardo da Vinci,—"Nature, in the composition of the human frame, has so ordained, that the face from the chin to the highest point of the forehead whence the hair begins, is a tenth of the whole stature; the same proportion obtains in the hand, measured from the wrist to the extremity of the middle finger. The head, from the chin to the top of the scalp is an eighth, and as much from the bottom of

* Paper read at the Royal Institute of British Architects.

Digitized by Google



J.D.Wyatt. del.

Feb.y 1859

J.R Jobbins.

NEW CHAPEL, ROYAL DOCKYARD, WOOLWICH.

G.G.SCOTT, A.R.A. ARCHT.

Digitized by Google

Digitized by Google

the neck.* From the top of the chest to the highest point of the forehead is a sixth; to the top of the skull, a fourth.† If the length of the face, from the chin to the roots of the hair, be divided into three equal parts, the first division determines the place of the nostrils; the second, the point where the eyebrows meet. The foot is a sixth part of the height of the entire frame; *the cubit* and the chest are each a fourth."‡

"The other members have certain affinities which were always observed by the most celebrated of the ancient painters and sculptors, and we must look for them in those productions which have excited universal admiration.

"The navel is naturally the central point of the human body, for if a man should lie on his back, with his arms and legs extended, the periphery of the circle which may be described about him, with the navel for its centre, would touch the extremities of his hands and feet." With respect to the extremities touching the periphery of the circle, it is clear from the diagram, that if the arms be raised above the horizontal, touching the top of the head, or not quite so high as the horizontal, the extremities of the hand will not touch the periphery. So likewise if the legs be expanded beyond the equilateral triangle, or more or less than 60 degrees, the feet will not touch the periphery.

"The same affinities obtain if we apply a square to the human figure; for, like the contiguous sides, the height from the feet to the top of the head is found to be the same as the distance from the extremity of one hand to the other when the arms are extended.

"The standards according to which all admeasurements are wont to be made are likewise deduced from the members of the body; such as the digit, the palm, the foot, and the cubit, all of which are subdivided by the perfect number which the Greeks call *teleios*."§

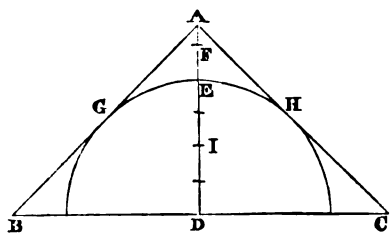
It will be observed that there is no such division in this ancient canon as that adopted by Audran, the Count de Clarac, and all modern artists,—the division of the head into four equal parts. It will also be observed that all the propositions here laid down relate to the longitudinal divisions of the human frame except only one, which bears reference to the width of the shoulders; for the transverse dimensions differ very considerably in every individual, and it is in these measurements alone that the difference between a Hercules and an Apollo, a Mercury and a Jupiter, are to be sought, but for which no law or canon is given.

With regard to the longitudinal proportions in this canon, however, I shall be able to show that they are the normal proportions of a full and well-grown man, equally removed from two opposite qualities of growth; namely, that quality of growth in which the characteristics of the infant are retained in a greater or less degree,—as for example, a large head, long body, and short extremities; and equally removed from that opposite quality of growth in which the characteristics of the adult are exaggerated,—as for example, a small head, a short body, and long extremities.

To illustrate the first mentioned quality of growth I have brought a small ancient statue of the Egyptian god Pthah, and for an illustration of the second quality of growth I must refer you to the engraving and description of a statue in the beautiful work of the Count de Clarac, vol. v. plate 840. The statue alluded to is in the marble of mount Hymettus, and therefore, probably, a Greek work, nevertheless it is remarkable for the disproportionate smallness of the head, and the length of the extremities.‖

Now, according to this canon, you will observe that the measure from the crown of the head to the sole of the foot is exactly equal to the measure from the extremity of one hand to the extremity of the other when the arms are extended. This exact equality of measure, we shall find, is the normal affinity or proportion which should exist between these two dimensions of the human frame; for if any given number of persons, whose occupations and habits of life are conducive to the full development of the structure, be measured, it will result that in nearly half the number the measure of the entire height will exceed, in various degrees, the measure of the extended arms; that in the other half the measure of the extended arms will exceed, in various degrees, the measure of the entire height; and that only a few in each section will correspond exactly to the proportion given in this canon. Thus, then, the normal proportion or affinity which should exist between these two dimensions of the human frame is established to be exactly equal, the mean measurement between the two great sections confirming the canon. In the same way, or by an analogous process, have all the other affinities recorded in the canon and set forth in the diagrams been ascertained.

I need not dwell in this room on the necessity of producing strictly (what may be called) geometrical elevations of the human figure in the elucidation of this subject, and also for explaining a most ingenious discovery appertaining thereto, by our celebrated countryman Mr. John Gibson, and by which in practice precisely the same proportions of the figure may be attained that have already been quoted from Vitruvius. This invention I am about to explain Mr. Gibson has allowed me to place in the hands of his brother artists in a small pamphlet on the subject of the proportions of the human figure.*



Mr. Gibson directs that the sculptor should draw a right angle triangle having the two sides AC and AB, that subtend the right angle, equal to each other. From the centre of the hypothenuse D, describe a semicircle which shall touch the lines A C and A B. Draw a line from D to the apex A. Divide this line from D to the periphery E, into four equal parts. Make EF equal to one of those parts. The diagram thus constructed contains all the dimensions of the principal divisions of the human figure. For instance, the hypothenuse B C represents a measure that is repeated three times. First, from the heel to the middle of the patella; secondly, from the middle of the patella to the superior spinous process of the ilium; thirdly, from the bottom of the abdomen to the pit of the neck. Thus the hypothenuse of the triangle furnishes the measure of the distances from each other of three very important points or divisions of the human figure, both in the perfectly erect position, and in that of standing at ease.

The sides of the triangle, AC or AB represent a measure that is repeated five times in the same figure; namely, first, from the top of the instep to the bottom of the patella; secondly, from the top of the patella to the pubis; thirdly, from a little above the navel to the pit of the neck; fourthly, from the top of the shoulder to the point of the elbow (of the straight arm); and fifthly, from the elbow to the knuckle of the middle finger. Thus the measure of five very important divisions of the human structure are ascertained by the sides subtending the right angle.

The remaining dimensions for completing the structure are contained in the line AD; for from D to I is the length of the neck, from D to E is the length of the face (measured from the chin at its juncture with the neck) to the highest point of the forehead. From D to F is the measure of the head from the chin to the top of the scalp, taken in the direction of the red line in the drawing; and lastly, from D to A is the measure of the foot from the heel to the end of the great toe.

All these measures obtain exactly when measured with the callipers on the finest Greek statues, and on the best living models; but you will observe, as indicated by the red lines on the drawings, these measures are taken obliquely, and in some instances inclining in two directions; as, for example, that from the heel to the middle of the patella inclines outwards in the front view, and forwards in the side view, which two obliquities reduce the vertical measure of the distance of the middle of the patella from

* This last sentence is irreconcilable, and does not occur in Leonardo's version.

† A *sixth* part is given to the distance from above the chest to the highest point of the forehead; and from the same point to the top of the skull is a *fourth* of the whole stature. In this sentence there is obviously a mistake in the numbers, which is corrected in part in Leonardo da Vinci's translation. It should be a *seventh* part is given to the distance from above the chest to the highest point of the forehead; and from the same point to the top of the skull is a sixth. The fourth is from the line which crosses the breast at the nipples to the top of the skull.

‡ Leonardo makes it a seventh. In the best antique statues it is something more than a seventh, but not quite so long as a sixth.

§ That is to say, those numbers (6 and 28) which are equal to the sum of their factors or divisors, were called τελειοι,—*e.g.* 3+2+1=6, and 1+2+4+7+14=28; and 6 is the number into which the cubit is divided.

‖ This statue was found in making an excavation in the Trastevere in 1849. It is larger than life, and represents an athlete using the strigillum, and is now deposited in the Museo Chiaramonti.

* 'Proportions of the Human Figure.' By Joseph Bonomi: second edition: Chapman & Hall, London, 1857.

Digitized by Google

the ground to the level, corresponding exactly with the middle of the patella, as obtained by the Vitruvian canon; so likewise do all the measures obtained by the triangle of Gibson coincide exactly with those designated or obtained by the four horizontal divisions or lines of the Vitruvian diagram. This accordance of the Vitruvian canon with the practical method invented by Mr. Gibson, is further demonstrated by the perfect similarity of both halves of the figure in the drawing, half of which is constructed according to the Vitruvian canon, and the other half according to the simple and practical invention of Gibson, a remark that applies equally to the two profiles of the same figure.

As before stated, all the proportions given by the triangle of Gibson obtained exactly when measured by the callipers on the finest antique statues, and on the best living models of both sexes; only those, however, which have but one inclination can be measured with the compasses on these geometrical elevations; this circumstance alone determines the inadmissibility of perspective delineations by way of elucidating the subject, for in drawings in which that essential element of the painter's art is admitted, no measure at all can be taken. The two profiles and front view of the same figure standing at ease are exhibited in the diagrams in strong black lines, while the faint red lines show the same figure in a perfectly erect position; by the change from the perfectly erect position to that of standing at ease one-fourth of the head, or in other words, a thirty-second part of the entire height is lost.

The centre of gravity is removed one inch and a quarter from where it fell in the erect figure of six feet high, namely, from between the ankles to nearly the middle of the ankle of the leg which sustains the whole weight of the body, while in the profile it remains where it was in the erect position. Also it is to be remarked that by this change of posture, where the black contour departs from the red contour on one side, there is an exactly corresponding departure on the opposite side, or, in other words, the excess on one side is balanced by an exactly corresponding loss on the other.

The remarks I have had the honour to address to you would be lengthened to an undue extent by referring to a work of Albert Dürer, on the 'Symmetry of the Human Body,'* illustrated by about two hundred woodcuts. However useful and curious this extensive treatment of the subject may be, it does not appear to me to supersede in any degree the valuable text of Vitruvius as elucidated by Leonardo da Vinci, and considered in connection with the practical discovery of our celebrated countryman, Mr. John Gibson.

THE APPLICATION OF STEAM TO AGRICULTURAL PURPOSES.

By W. Bridges Adams.

In the course of a valuable paper on "the Culture of Food," by Mr. Adams, published in the *Journal of the Society of Arts*, he makes the following remarks upon the application of steam to agricultural purposes—the importance of which induces us to quote them. After advocating the deposit of heat and manure in the form of steam or hot water combined with charcoal manure, by pipes *under* the soil (where the roots of the plants may find and appropriate them), instead of *upon* the soil, where they escape,—Mr. Adams says:

"Connected with railways for a long period, one of my principles was that the hard iron surface, which diminished friction and economised labour in transit, must be still more suitable in the process of working the land, where both transit and labour were requisite. In the year 1845 I wrote an article in the *Westminster Review*, propounding the theory of rails on cultivated land for the purpose of supplying steam power, then supposing stationary power:

'In farm districts the power need only be applied to road purposes when required, using it for farm purposes at all other times. In sober earnestness we propose to convey artificial heat beneath the earth on open land, so as to maintain the temperature suited to the growth and development of the vegetable tribes, by means of pipes of metal or earthenware circulating steam or hot water or air from a close boiler or stove: these pipes to be laid at depths of 4 to 5 feet, in the manner of deep draining. Also, by a similar process to inject the ground with gaseous manure, as ammonia and carbon, so that the heat and gases may be constantly ascending towards the surface, and thus be absorbed by the roots of the plants. We shall yet see the time when rails will be laid along the surfaces of our fields, whereon cylinder harrows will traverse, driven by the same stationary power, to break the soil into fragments fit for the growth of plants. When our land shall be drained, dried, moistened, heated, cooled, and injected with liquid and gaseous manures at pleasure, and moreover cultivated by power machines, we may be truly said to have conquered the earth, or a portion of it.'

Nothing practical that I am aware of came of this, though sundry "improvers" and projectors pronounced the idea "ingenious." Still, the ideas of heat and manure *injection* in opposition to surface applications, and the application of rails and steam power, remained in my mind a conviction, though not demonstrated publicly, to which I recurred from time to time in publications, other pursuits rendering it difficult for me to aim at practice. Early in 1850 I published a work called 'Road Progress,' advocating the amalgamation of railways and highways for agricultural improvement and steam farming in Great Britain and the colonies. The following is an extract:

'From the towns the parish roads diverge, and rails laid on them might be carried direct into the farmyard. Here, then, we have the produce at one end of the line, and the metropolis or other town at the other end.....From this farmyard lines of moveable rails would be found well adapted to take the dunging and manure by horse-trucks to the centre of each field; or a farm locomotive might be established thereon, a proposition not for ploughing, but for doing the same kind of work better by harrowing; or it might be used to pump water up to drain away, or to pour over the fields in irrigation; or to inject manure or heat, or both combined, beneath the surface of the land for the sake of improved produce. With a small portable saw-bench and morticing machine ready to connect to the engine, the farmer might, with the rude skill of his own farm labourers, construct from time to time all the woodwork he might require, as is the common practice with farmers in the United States. It is difficult to estimate the importance of carrying coals by rails direct into the farm. From that time the farm will take rank with the factory in labour-saving processes, and the production of food will be so cheapened as to put to rest for ever the fear of foreign competition. Without cheap coal farm operations can but be very imperfect.'

My next attempt at agitating this question of railways into farms with steam culture was, if I recollect, in a paper read before the Society of Arts, in December 1850.

'Siding rails would run into farmyards, and the markets would be at the stations and termini. Coals being thus borne cheaply on to the farm, farm machinery would rapidly increase, and farm labourers would acquire mechanical skill. Temporary rails would become a farm utensil, as they are now in the hands of road contractors, and contrivances innumerable would be the result.....And not mere grain and meat would be produced on the farms, but the heavy class of vegetables so important as human food, but which hitherto no town has possessed up to the extent of its consuming power.....The power of the locomotive might also be applied to inject land with steam-heat and gaseous manure through the system of drain-pipes. There is yet needing an influential landholder to be to the agricultural railway-maker what a Bridgewater was to the canal-maker, and a Devonshire has been to the horticulturist,—to multiply manifold his own revenue, while being the world's benefactor.'

In 1851, in an article in the *Westminster Review* on the Industrial Exhibition, I again agitated the question:

'Unless the rails so laid on occupation roads shall have one terminus in the farmyard and the other in the market, either directly or in communication with main lines of railway, the maximum of cheap transit for produce will not be attained. When this shall be done, and it will probably be by the agency of rails inserted in the surface of ordinary highways, the costly and artificial labour of the farmer in shifting his loads will cease, and the saving will become perfect.

'But there is more than this to which we have called public attention before. There needs a system of rails for transit on the farms. Time will show that permanent ways, as well as moveable, will be needed; but permanent way means a new laying out of the farms in rectangles, to which the system of steam digging may be applied,—not steam-ploughing, for ploughing is

* 'De Symmetria partium humanorum corporum.'

Digitized by Google

a process that never would have been invented had not horses and oxen been invented first. We do not plough with man-power, neither can we with steam-power to advantage.'

After the Great Exhibition I was not one amongst those disposed to scoff at the "agricultural mind." Considering their isolation from the hands of thickly congregated men in cities, the wonder really was how much the farmers had accomplished, and not how little. Considering that working farmers possessed but small capital, and mostly short leases and no freeholds, it was not wonderful that they did not dream of bringing the machinery of a cotton mill on to the land, and those who possessed the capital, the landlords, had but little belief in steam. Lord Willoughby D'Eresby did try to turn a locomotive to account by a system of ropes, but this was a failure, and most plans since have had reference to drawing ploughs by ropes. The practicability of using an engine bearing on the soil to dig by steam-power and propel itself has been much mooted, but till the advent of Mr. Boydell's engine it was an impracticability, and of questionable advantage even with that. My own view of the process of earth working was thus expressed in the article on the International Exhibition:

'For heavy land there needs a revolving engine made to cut with the sides, with an advancing movement, precisely as grooves are cut by machinery in wood. When there is hard work to do circular movement is the only method, whether for wood carving, metal turning, timber sawing, or earth cutting, and we are not sure that a series of vertical drills on a large scale, of the size of spades, cutting the whole surface to a sufficient depth, and travelling forward at the same time, would not be the most efficient mode of ploughing. We incline to think that the time will come when ploughing and drilling, sowing and harrowing, will all be performed at a single operation, like paper making. It is but getting together a mass of earth spinning-jennies, of stronger construction than those used for cotton and flax. The only impediment is too much moisture, but this may always be avoided by sufficient drainage.....We apprehend that it will be in the north—in Lancashire or Yorkshire—that the first strides will be made towards obtaining the real possession of earth for the purposes of agriculture.'

Thoroughly convinced of the practicability of such a system of cultivation by steam machinery combined with rails, I had purposed, amongst other projects, to give my imaginations practical effect, or rather to combine existing practice into a whole whenever leisure might obtain. It was therefore with no small pleasure that I listened to the paper read by Mr. P. A. Halkett before the Society of Arts, on the 8th of December last, on 'Guideway Agriculture, being a system enabling all the operations of the farm to be performed by steam power.' It was not left for Lancashire or Yorkshire to do this thing, but to Peter Alexander Halkett, of the Windham Club, St. James's, in our own London, and I understand a naval officer to boot, and not an agriculturist; showing that now, as often before, improvements come from outsiders looking on rather than from regular practitioners.

To any competent mechanic the diagrams would have sufficed without the paper, but on the following day I visited Mr. Halkett's machinery at Kensington, and found in Mr. Grafton a most intelligent and practical exponent of the whole system, which in general terms amounts to this:

The travelling platform frame of the builder, such as we see at the Houses of Parliament and Westminster Bridge, and at Portland and Holyhead, moving by man-power on rails on the tops of high scaffolds, is enlarged in width and breadth, and placed on rails on the surface of the land to be cultivated, raised to such a height as to clear the plants, and, instead of man-power, is moved by engine-power, which also serves to put in operation the various tools required for dealing with the land. The tramway frame of the builder is thus practically married to the portable engine of the farmer, and is furnished with tools from the workshop of the engineer. The mill that cuts iron like cheese has ceased to be a fixture, and is made moveable over the face of the land, to cut and carve the soil into fragments, to rake it into fine mould, to free it from weeds, and clean it from stones if needed. This at Kensington is the practical germ of the process that will multiply four-fold the farmer's crops; that will convert the farm labourer from an ill-clad uncultivated human being, into a well-clad intelligent mechanic, working under shelter from the sun and rain, and with all the advantages of fresh air for his workshop; that will enable this intelligent mechanic to work on a sugar or cotton plantation, with a steam fan if needed, keeping his body constantly cool; that will give to the man the practical dominion over tropical labour he thinks now only attainable by the negro; that will make as great a revolution for humanity as was done by the advent of railroads, which destroyed the practice of cruelty in overdriving post-horses; that will render the night equally available with the day for all the processes of cultivation. The plough, the harrow and the hoe, the rake and the dibble, broad-cast and drill sowing, may all be set in motion by steam, and hoeing between rows of wheat may at last be accomplished.

For the purpose of depositing liquid manure at the roots of the plants instead of on the surface Mr. Halkett has constructed a tool in imitation of the tooth of the poisonous serpent or the sting of the wasp. The liquid exudes through the end of the pipe which cuts the trench, below the surface. But there is yet a very important tool that requires adding,—a vertical drill with cutting edges, which, as it advances, will comminute and aerate the soil between rows of plants, and produce a far better result than the man-hoe.

The tank carried on the platform will be very available for liquid manure, but for the purpose of general irrigation a new method is desirable, as it would be impossible to carry sufficient water on wheels. Perforated pipes of earthenware should be deposited at two feet depth below the surface, provided with entrance for the water but no exit. These pipes being filled from the nearest level, the water will be absorbed by the spongy superincumbent soil, and carried to the plants without caking the surface. This is a most important process, for it will render level uplands more valuable than the low-lying lands called meadows usually selected for market gardens, as Greenwich and Deptford.

An arrangement of this kind would be peculiarly adapted for hot climates, were it only to save water. The valley of Valencia in Spain is a large triangular plain, sloping into the Mediterranean between two lofty mountain ranges, which unite where the river rushes down. This river, the Guadalquiver, would be in the warm season wholly absorbed for the purpose of useful irrigation, but probably one-third of it is evaporated by the sun, and another third wasted on surface weeds; and the scarcity of water is so great that perennially faction fights occur amongst the peasantry quarrelling for water, which have to be put down by the soldiery, and though scarcely a drop reaches the sea, large quantities of fine land lie waste.

On this system of cultivation by machinery it is obvious that a straight surface of soil is the best, and that a level surface will involve less power than an incline. It is obvious also that the longer the run of the machine the more convenient will be the operation and the less the cost of rails, as there will be less proportional amount of heading; and doubtless, as the system goes on, levelling of the soil will take place, as on roads, to facilitate draught. Other things being equal the level surface will be worked at less cost than the incline, as is the case when horses are used.

I now come to the question of the rails and machinery as set out by Mr. Halkett.

To work a railway economically with the least consumption of fuel it is essential that the rails should not deflect either vertically or horizontally. The greater the pressure the stiffer the rail must be, and the shorter the length over which that pressure extends the greater must be the strength of the rail. If traction be performed by the adhesion of driving wheels, the greater the number of driving wheels with a given load the more the pressure will be distributed, and the lighter may be the rail. As the cost of the rail is proportionately greater than that of the machine Mr. Halkett prefers to use light rails and a large number of driving wheels.

On an ordinary line of railway the wheels have a single flange in the inside, and the peripheries are in the form of cones and not of cylinders. The object of this is to compensate for curves on the rails. The result is a greater pressure tending to force the rails out and widen the gauge. For this reason strong cross tiers are essential to hold the rails together. For the purpose of cultivation these cross tiers are inadmissible, and therefore the wheels of the machine must be made cylindrical and with two flanges. In this mode there will be no tendency to vary the width of the gauge.

In using a single pair of wheels for the purpose of propelling in a straight line there should be no rubbing friction, provided

Digitized by Google

the wheels are exactly of the same diameter. And whatever is the number of the driving wheels the exactness must exist both in the peripheries and in the crank pins and connecting rods, or in the connecting chains if chains be used. It becomes therefore a question between stiff rails and few drivers, or light rails and many drivers, as to cost. If cast wheels be used not turned to exactness in the lathe some compensation must be provided to prevent the rubbing of the tyres on the rails, which would soon destroy both. Mr. Halkett, dealing at present with very flexible rails, which can scarcely be permanent, does not sufficiently estimate the amount of this difficulty which will occur when solid machines and sufficiently firm rails are used. Moreover, if stiffness be not provided in the rails, it must be in the frame. A flexible frame would not distribute the load, but would suffer every wheel to sink into the successive hollows.

The rail Mr. Halkett has chosen—a light single iron—is the worst form for strength that can be contrived, unless we suppose it to be firmly fastened down to a solid base. I have used such rails for light purposes in machinery, but it is a serious objection that they deflect vertically and widen literally, decreasing their vertical strength rapidly as their load increases. If with a given weight of metal Mr. Halkett does not find his rail deflect it will simply prove that he is using iron in waste.

The system is made to depend not on the strength of the rail itself, but on the substructure of burnt clay or concrete 15 inches wide. The cost is stated at £20 per acre, leaving a serious nuisance on the ground if at any time the course of the rails need be changed. There is no need whatever for this substructure, for at the same cost a self-contained rail of great strength can be applied on the surface in such a mode that it can be taken away without any waste, and removed to another position when required. If a rail be used so weak as to depend on substructure there will need a constant patching and mending. If a stiff rail be used the ordinary surface will be sufficient.

The frame, pair of engines and tools, are estimated to weigh about 24 tons, on twenty-four wheels, or a ton per wheel. As this weight is all adhesive or propelling, it will be equivalent to 6 tons of traction force, supposing no undue friction. If cylinders of 6 inches diameter be used with a 4 feet wheel and 16 inches stroke of piston, the locomotives will give out about 2580 lb. at the periphery of the wheel, and as little more than 250 lb. will be needed for the purpose of propulson at 13 lb. per ton, 2250 lb. will be left to work the machinery at a speed of 10 miles per hour.

But, if instead of a level there be an incline of one in 100, the resistance to traction will absorb about 740 lb.; on an incline of one in 25 about 2312 lb., nearly the whole force.

If the driving wheels be worked at a slower speed, with a toothed pinion at the periphery, there will of course be more available power for the machinery.

The system of Mr. Halkett in making a double engine for an enormously wide gauge by a connecting beam, thus keeping the chief load direct on the rails, displays great ingenuity, but whether the multiplicity of driving wheels in connection with it for the sake of a light rail will prove the best system remains yet to be seen, and it would be quite worth while to try the plan of Mr. Boydell with a similar structure.

There is little doubt that a gauge of 60 feet may be worked on this system, which will only require 250 yards of rail per acre, including headings, calculating a farm of a square mile or 640 acres, at a cost of £20 per acre, or £12,800 per mile. The machine may be estimated at £2000, making a total of £14,800, which for interest and materials will be £3 annual per acre. But the machine will go over the whole mile in forty-four hours, say three times a week, so that 4 square miles may be estimated to one machine. Reflecting that the rails of 4 square miles, or 2560 acres, only weigh 2500 tons, and the machine 25 tons—total weight 2025 tons, and total cost £53,200, and total annual interest and material £6384—it does not seem a matter beyond the reach of a company of tenant farmers with a moderate long lease, inasmuch as they can carry off the whole of the materials at the end of the lease, and the more especially with the probability of a double crop off the same extent of ground at half the cost of labour.

If this manifestly practical plan, doubling the strength and power of the English nation, be suffered to lie in abeyance, it will be a standing satire upon the agricultural bodies, ranking amongst them the oldest traditional names of our country."

BINOCULAR VISION.*

Of the thousands who gaze with delight upon the magical effects produced by that small instrument known as the stereoscope there are few who comprehend or attempt to assign reasons for the extraordinary optical illusions experienced through its instrumentality.

The following may assist in elucidating the principles of vision upon which these are founded:

It will in the first place be well to consider the difference between monocular and binocular vision. Nature has furnished us with several means of determining the distance of objects which may happen to come within reach of our visual organs. One is that of distinctness, a greater or lesser degree of which—other things being equal—gives an idea of greater or lesser distance in the object viewed. The second is through the change of focus required in the lens of the eye in refracting to a point on the retina, rays of light entering it with a greater or lesser degree of parallelism, thus producing in the brain a consciousness of unequal distances in the objects from which they emanate. The means above alluded to, it is evident, are enjoyed in almost the same degree when viewing with one eye as where both are used. By far, however, the greatest power with which nature has endowed us of discriminating distances is through the agency of binocular vision; or in other words, in the sensation produced in the brain by the different degrees of convergency of the optic axes required in obtaining distinct vision of the differently distant points of objects upon which they are directed. It is to this faculty that we are indebted for our most palpable evidence of differential distances, and for that consciousness of solidity and relief so remarkably experienced in the stereoscope.

It is evident, for example, when we are looking at a house or other object that has depth as well as breadth, from such a point of view as to enable us to see two sides of it at once, that we receive a differently perspective image upon the retina of either eye, or that we must see more of one side and less of the other with the right eye than with the left, or *vice versâ*. Thus accomplishing with one view what a person with but one eye would require two views at positions 2½ inches apart—the distance between the eyes—to accomplish. These are the differently perspective views of the stereoscopic cards, and it is the effort to reconcile these dissimilar pictures by converging the optic axes at points differently distant from the eyes which produces the wonderful effect above alluded to, and which enables us to experience all the sensations of delight which would be produced by the contemplation of the landscape itself. The stereoscopic pictures will of course never quite correspond. They are taken simultaneously with a camera constructed with two lenses, or consecutively with a camera with one moveable lens. The lenses of the stereoscope, besides magnifying the pictures, are so placed as to unite certain similar points of them, thus relieving the eyes of too great effort in uniting them entirely by convergency of the axes.

The means above alluded to, by which we are enabled to judge of differential distances, are of course much diminished by the distance that the objects viewed are removed from us. Our consciousness of different distances by distinctness is diminished through decrease of light. Our judgment through change of focus is diminished in consequence of the parallelism of rays from distant objects being so nearly the same as to require but little change in refracting them to a point on the retina. And lastly, the binocular effect is in a great degree impaired through the identity of distant views when seen from positions only separated by a base of 2½ inches. Nature has thus observed her usual economy in providing for our necessities alone. It being of little comparative importance to us generally to be acquainted with the relative positions of distant objects, whereas our personal convenience and even safety depend greatly upon our knowledge of those near at hand. We are therefore provided with much more ample means of determining the latter than the former.

It may not be out of place here to allude to another subject immediately connected with vision.

Sir David Brewster says, in allusion to the cause of erect vision from an inverted image, "That it has long been a problem among the learned." And further remarks, "That it is perfectly explained by the law of visible direction." Now, although it is evidently a consequence of that law, the question arises, why should we see objects in a direction perpendicular to the retina at

* From the Journal of the Franklin Institute.

Digitized by Google

Digitized by Google

RAILWAY SPRINGS.

Fig. 1.

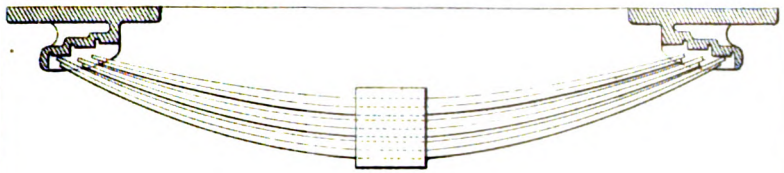


Fig. 2.

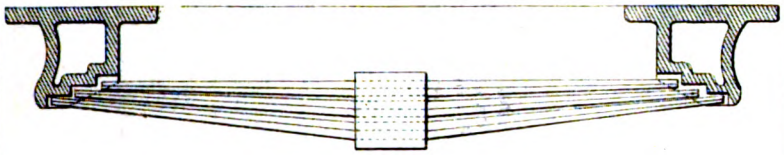


Fig. 3.

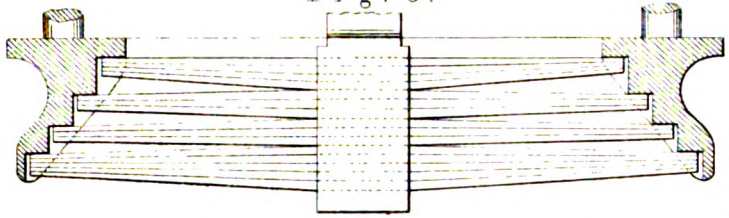


Fig. 4.

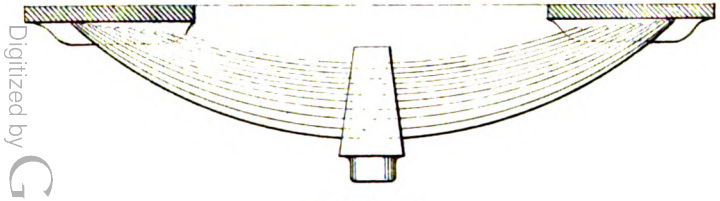


Fig. 5.

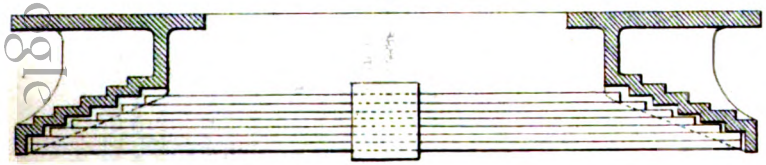
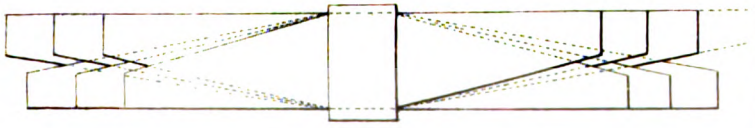


Fig. 6.



AXLEBOX AND COUPLING BAR.

Fig. 3.

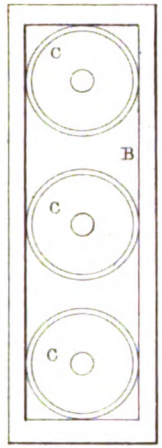


Fig. 1.

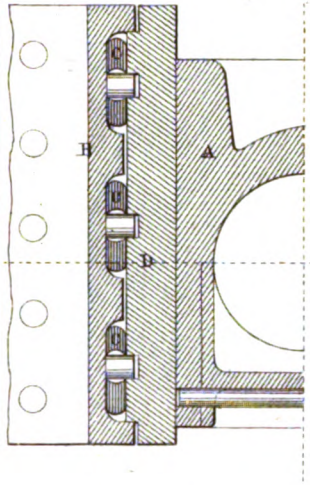


Fig. 4.

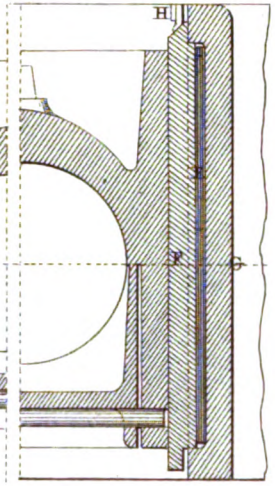


Fig. 2.

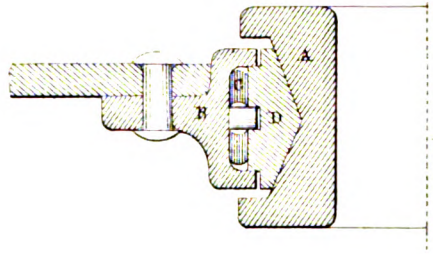


Fig. 5.

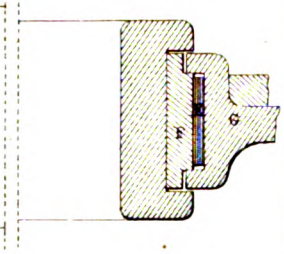


Fig. 6.

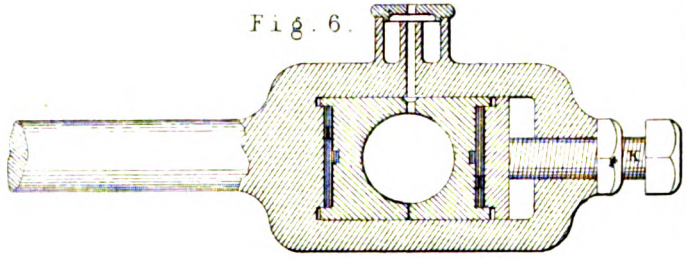
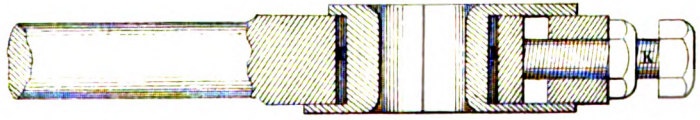


Fig. 7.



WOOD BEARINGS.

Fig. 1.

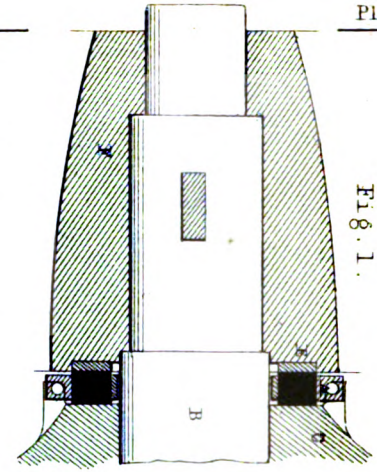


Fig. 2.

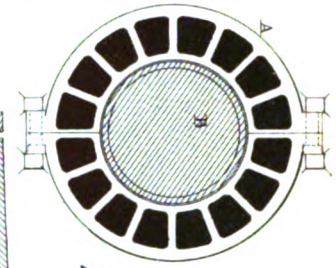


Fig. 3.

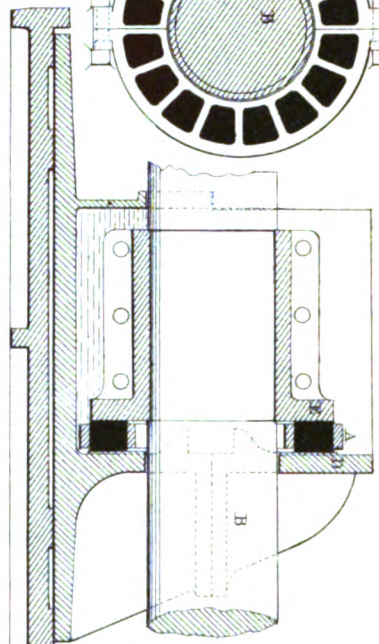
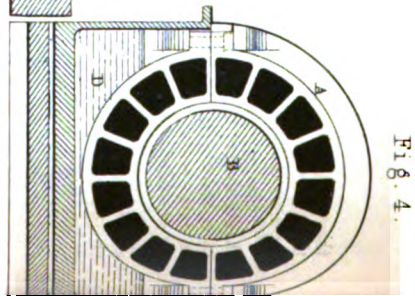


Fig. 4.



Digitized by Google

the point where their image meets it? In truth it is one of those facts that require no explanation, as there is nothing inconsistent or irrational in it.

There is no more reason that an inverted image should give us the idea of an inverted object than that the reverse should be the case, or that it should give the idea of a horizontal one. There is no unity necessary between the direction of an object and the direction of its image upon the retina. Nature has so associated impressions upon the retina with impressions on the brain that an inverted image on the former is evidence of an erect object to the latter. And we have no consciousness of anything to the contrary.

AXLEBOXES AND COUPLING RODS FOR LOCOMOTIVE ENGINES.

By W. A. Fairbairn, C.E.

This construction of axlebox has for its object the introduction of an elastic cushion or spring of vulcanised india-rubber between the axleboxes and framing of locomotive engines, for the purpose of allowing the wheels to accommodate themselves to curved portions of the railway, and thus to diminish the wear on the flanges of the wheels and on the faces of the axleboxes. The india-rubber spring is placed in recesses formed in the jaws of the horn plates upon each side of the axlebox, and a metal plate with a smooth casehardened surface is interposed, upon which the axlebox slides vertically with the inequalities of the road. The force of the spring action of the india-rubber is made sufficient to keep the axles of the wheels at right angles to the straight portions of the railway, but to yield to the friction of the rails upon the wheels in curved portions, and by this means to allow the axles to assume such a position as will place the wheels at a tangent to the curve. The elasticity of the india-rubber serves also to keep the axleboxes at all times in close contact with the faces of the horn blocks, so as to secure a good fit, and obviate the necessity for that constant lining which they ordinarily require in consequence of the wearing away of the working faces.

The construction of the axleboxes is shown in figs. 1 to 5, Plate V., which represent the india-rubber applied to the trailing or leading, and to the driving wheels of a locomotive engine. Fig. 1 is a half section, and fig. 2 a plan of an axlebox of the leading or trailing wheels; and fig. 3 a side view, showing the position of the india-rubber washers.

A is the axlebox itself, B the jaws of the horn plate between which the axlebox slides; these jaws are recessed to contain the india-rubber springs C, and the face plates D whch cover them. These plates are casehardened, and hence form an exceedingly smooth surface for the axleboxes to slide on; they rest upon the india-rubber springs C, and a space of $\frac{1}{8}$ inch is left between them and the jaws B of the horn blocks, allowing the axlebox to play $\frac{1}{8}$ inch either way in the direction of the length of the engine, whenever the strain upon the wheels is sufficient to compress the india-rubber to that extent. That the leading and trailing wheels may have still further flexibility of adjustment, a small play is permitted to the axlebox laterally in the direction of the axle by making the recess in the axlebox, in which the plate D slides, wider than the plate itself by $\frac{1}{2}$ inch. But to keep the axleboxes in position in straight portions of the road, the plates D are made wedge-shaped in plan, so that the elasticity of the india-rubber restores the axleboxes to their central position whenever the pressure on the flanges of the wheels is relieved. The inclination of the wedge is made such that $\frac{1}{4}$ inch movement of the axlebox laterally in either direction compresses the india-rubber $\frac{1}{8}$ inch.

The india-rubber is employed in the form of rings or washers $\frac{13}{16}$ inch thick; and it is found convenient, in order to maintain an accurate fit between the working surfaces of the axleboxes, that these washers when in position should be compressed $\frac{3}{16}$ inch, which is equivalent to a pressure of about 1 ton on each side of the axlebox, tending to maintain the contact of the working surfaces. With this pressure the axleboxes slide more freely on the casehardened surface of the plates D than in the usual construction; whilst the motion which permits the wheels to accommodate themselves to the curvature of the road does not in the least increase the oscillation of the engine, and prevents the excessive wear of the shoulders of the journals and of the flanges of the wheels, which are such fertile causes of unsteadiness in ordinary engines. A specimen was shown of the vulcanised india-rubber taken from the axlebox of the leading wheel of an engine, in which it had run 17,000 miles; it is still uninjured, and retains its elasticity as perfect as when first introduced.

In the case of the driving wheels of the engine, it is not advisable to allow so much play to the axleboxes; and hence, whilst the admirable fit between the working surfaces obtained by the above arrangement renders its employment advantageous, it is modified in this case, as represented in figs. 4 and 5, which show a half section and plan of an axlebox for the driving wheels of a locomotive. The india-rubber E consists of a flat band $12\frac{1}{2}$ by $2\frac{1}{2}$ inches and $\frac{3}{8}$ inch thick. It is covered by a wrought-iron plate F, casehardened as before, but not wedge-shaped, since in this case all lateral play is to be avoided. A longitudinal play of $\frac{1}{32}$ inch only is allowed on each side between the casehardened plate F and the horn blocks G, to permit the action of the india-rubber spring, which is compressed in this case so as to exert an initial pressure of about 15 tons on each side of the axlebox to resist the action of the force driving the engine. Notwithstanding this large pressure on the working faces of the box, it is found in practice to fall readily with the weight of the wheel itself. In the case of the driving wheel the advantage derived by this construction does not consist in the adjustment given to the wheels, but in the perfect fit at all times maintained between the sliding surfaces, the elasticity of the india-rubber making up for the wear of the axlebox, and obviating the necessity for lining up after a short period of running. The india-rubber also forms an elastic cushion to receive the shocks of the machinery. A small strip of leather shown at H, fig. 4, prevents the oil from gaining admission to the india-rubber.

The perfect freedom of motion, the small wear of the axlebox in consequence of the casehardening of the slides, the ease with which the engine passes curves, and the diminished wear of the wheel flanges are important advantages, which have been derived in practice from this construction of axlebox.

In figs. 6 and 7 is shown a similar application of an india-rubber spring I, to the outside coupling rods of an engine. In this construction of rods the use of cotters for tightening the brasses is dispensed with by employing a set screw K, at the end of the rod, secured by a lock-nut from risk of working loose. —*Inst. Mech. Eng.*

WOOD BEARINGS AS APPLIED TO THE SHAFTS OF SCREW STEAM VESSELS.

By John Penn.

Wood Bearings have been applied to the main bearings of screw shafts of steam vessels for the purpose of overcoming the serious difficulty experienced in the rapid wear of the ordinary brass bearings of those shafts. The application of these wood bearings has recently become greatly extended; and prolonged experience has given a remarkably favourable result in their durability and the small amount of wear to which they are liable.

One of the first cases of the application of these wood bearings was in H. M. steam sloop Malacca, of 200 horse power; these have now been at work three years and a half, and the result has proved completely successful. After the vessel had been at work a short time with bearings of brass, as usual, the bearings showed immediate signs of wear, and the same brasses were grooved out and small strips of lignum vitæ were put in, and although the screw shaft bearings were somewhat cut and rough, the wear of the wood was very little after running 15,000 miles; a very severe test, and where the bearings are quite new when the wood is applied, the wear is really nothing.

It was found previously that where brass and brass were used in bearings the wear was so great that repairs had frequently to be made, at great expense, after a run of 2000 or 3000 miles. The weight on the screw bearings is about 70 lb. per square inch; but from the experiments made it appears that ten times this weight might be applied with the wood bearings, and the wear would after running some years be practically nothing. Where the wood has been applied to smooth bearings, or bearings in good order, no renewal has in any instance been required, although some vessels were fitted as long ago as December 1854.

Digitized by Google

All the Government screw ships are now fitted with these bearings, and the system is coming into general use. It perhaps may be asked why iron shafts running on brass were not generally used: this would not do in wood ships, for it was found the iron bearings became rough and unequal from the chemical or galvanic action of the copper sheathing of the ship; but even in iron ships no bearing of whatever description has been found free from defects, except the wood bearing. It is always desirable where practicable to cover the iron shaft where it runs on the wood with a brass bush or covering; for an iron shaft, if the ship lies by idle for a few months, becomes rusty and tends to damage he bearing. This is the only advantage of covering the shaft with brass, for the wood wears as well on one metal as on the other, if kept constantly at work.

The mode of applying the wood bearings to the main bearings of screw shafts was described in a former paper, the wood being employed in narrow strips placed flatways of the grain, fixed in dovetailed grooves cut longitudinally in the brass bearings, with narrow spaces left between the strips of wood for a current of water for lubrication and to keep the bearing cool. This original construction is still adhered to and found quite satisfactory.

In figs. 1 to 4, Plate V. accompanying the present paper, is shown a more recent application of the wood bearings to receive the end thrust of the screw, by means of a large collar fixed upon the shaft at the screw or at any other desired position, which is capable in this construction of taking the entire thrust of the screw, thus removing the strain from the other bearings of the shaft or from the crank.

In this arrangement the pieces of hard wood, shown black in the figures, are fixed endways of the grain in a series of recesses or sockets in a brass disc A, through which the screw shaft B passes freely. This disc is either fixed to the stern-post C of the vessel, as in fig. 1, when the entire thrust is to be received at that point; or it is fixed to a cast-iron bracket or pedestal D, as in fig. 3, when it is required to take the thrust at a point of the shaft within the vessel. The pieces of wood project a little beyond the face of the disc A, and work against a brass ring E, which is fixed on the front of the screw boss F, as in fig. 1, or secured by a clip upon the shaft at the required position, as in fig. 3. The disc A and ring E, fig. 3, are both made in halves, bolted together by flanges for convenience of fixing.

When the wood bearings are outside, as in fig. 1, the lubrication is effectually provided by their continued immersion in the water; and in the case of the inside bearings, the pedestal D is cast in the form of a trough for containing water, as shown in fig. 3, by means of which the lower part of the bearing is kept constantly immersed in water.—*Inst. Mech. Eng.*

A NEW CONSTRUCTION OF RAILWAY SPRINGS.

By Thomas Hunt.

A considerable portion of the material used in the construction of the ordinary laminated steel spring gives, in the writer's opinion, but little elastic action, and in fact acts more as the base upon which the other portions of the spring deflect; and hence he has been led to the conclusion that two important defects are inherent in that principle of construction, namely, a superfluous dead weight of material used, and an unequal strain upon the several portions of it. It then occurred to him that if the plates of a laminated steel spring could be arranged so as to act upon the principle of a series of beams directly connected with each other, and so that the number of plates in action might be determined to some extent by the load (which in all carrying vehicles such as tenders, carriages, and waggons, is well known to vary considerably), these defects would be removed, and a spring of the greatest practicable strength with the minimum quantity of material be the result. Many experiments were made to clear up these points, all of which proved conclusive as to the superior strength and elastic action of the plan of spring described in the present paper over the common construction.

Various modes of constructing this spring are shown in Plate V. The cast-iron shoes are made with a series of steps, and the ends of the plates bear independently on the several steps of the shoes; the whole spring being inverted as compared with the ordinary springs, the bottom plates being the longest. Each plate is arranged to carry its proportion of the load independently to some extent of any other plate, by the steps being made gradually deeper in succession, so that only the longest plates bear at first, and the other plates take a bearing successively as the deflection of the spring increases, giving a uniform elasticity under a variable load.

By tapering each of the plates in thickness or in breadth from the centre to each end, a uniform deflection of the plates throughout their length is obtained. The result of this mode of construction is that a spring about two thirds the length of an ordinary spring gives out as much elastic action; whilst if the same depth be retained its carrying power is much increased; and hence it follows that to do the same work a much lighter spring will suffice.

The facility for giving as much deflection as may be deemed necessary to each plate independently is an important improvement in this construction of spring, as it avoids any undue proportion of the work falling on such plates as from their length should not receive it. In consequence of the independent action of each plate, they are not required to be fitted to each other as in the ordinary make of springs, and hence their cost of manufacture is lessened by the expense of so much fitting.

In Plate V. are shown the different forms of these springs that have been used.

Fig. 1, a wagon spring with curved plates tapered in thickness.
Fig. 2, a wagon spring with straight plates tapered in thickness.
Fig. 3, an engine spring with straight plates tapered in thickness.
Fig. 4, a tender spring with curved plates tapered in thickness.
Fig. 5, a tender spring with straight plates tapered in breadth.
Fig. 6, a plan of the spring shown in fig. 5.

The following table gives the particulars of experiments made on the comparative weight and deflection of the new springs and of springs of the ordinary construction:

Description of Spring.	Weight of Steel.	Length of Bearing.	No. of plates.	Breadth of plates.	Thickness of plates.	Camber.	Load	Deflection		Permanent set.
								Total	Per ton.	
	lbs.	Ft. Ins.		Ins.	Inch.	Ins.	Tons.	Inch.	In.	In.
Common spring	98	2 7½	12	3½	⅜	2½	2·70	1·62	·60	0.12
New curved spring	60	1 10	9	4	{ 1×⅜ / 8×¼ }	1⅜	2·70	1·12	·42	0·12
Common spring.	78	2 0	7	4	⅜	4½	2·05	0·75	·37	
New straight spring...	66	2 9	6	4	⅜ to ⅛	⅜	2·05	0·69	·34	
New curved spring	56	2 4	6	4	⅜ to ¼	1⅜	2·05	0·62	·31	

The wagons in which the new springs are working are 14 ft. 6 in. long, by 6 ft. 2 in. wide, and 1 ft. 6 in. deep inside, and intended for 6 tons load; but they have been frequently loaded to 9½ tons, and the straight springs were then deflected downwards about ½ inch, but were still doing their work efficiently, no failure having occurred with them.

There are now about 350 of these springs in use on wagons and tenders upon different railways; several have been two years in regular work, and the results are very satisfactory, none of them having failed.—*Inst. Mech. Eng.*

REVIEWS.

On Telegraphic Cables. Excerpt 'Minutes of the Proceedings of the Institution of Civil Engineers.' Vol. xvii. 1858.

On the Mechanical Conditions of the Deposit of a Submarine Cable. By G. B. Airy, Astronomer Royal. 'Philosophical Magazine,' July 1858.

On the Atlantic Cable. By William Gravatt, F.R.S. 'Philosophical Magazine,' July 1858.

Resuming from our last number the review of the mechanical investigations contained in the papers above cited, we proceed to consider the investigation by the Astronomer Royal in the *Philosophical Magazine* of July 1858. The principal results of this investigation appear to have been given by the Astronomer Royal in a paper read at the Institution of Civil Engineers in the preceding April. In the abstract of that paper, given in the volume first above cited (p. 141), Prof. Airy is reported to have said that "the desire to arrive at accurate instead of approximate results, had induced further investigations and new records of their results. It had lately been stated to him that the terminal velocity of the cable in falling through water would not much exceed 3 feet per second. This led to more accurate investigations, in which no part of the resistance of the water was omitted; and the general result was that for the safe circumstances, when the angle of inclination of the cable on leaving the ship ap-

Digitized by Google

proached very near to the limiting or critical angle, the views expressed by Mr. Gravatt were correct, the numbers given by Prof. Airy in a former table being considerably too large; and that for dangerous circumstances, when the cable on leaving the ship was very little inclined to the horizon, the numbers in the former table were very nearly correct." The former table here referred to is given at page 81 of the same volume, and was submitted to the Institution in the course of a discussion there.

The paper now to be considered comprises three distinct subjects: 1. The investigation of the form and tension of the cable when travelling forward and payed out uniformly, but not subject to any resistance from the water. 2. The investigation of the same things when the resultant resistance normal to the cable is assumed to vary directly as the velocity, and the law and coefficient of tangential longitudinal friction are assumed to be the same as for the former resistance. 3. The investigation of the same things when both resistances vary as the square of the velocities, and the application of that investigation to the case in which the cable assumes the form of a straight line. We shall notice each subject successively.

In investigating the form and tension of what is denominated the "travelling curve," when not subject to resistance, it is assumed that the form of the curve is always the same. Of course this is a possible case, and as Prof. Airy has made the same assumption for the cases where the resistance acts, without assigning reasons for the assumption, it may not be out of place to show that the assumption is reasonable. The most general case is of course that in which the cable has an oscillating motion, and doubtless it is in practice subject to oscillations. But where the velocity of paying out and that of the vessel are perfectly uniform, it may be safely considered that after some time the oscillations will cease, for it is clear that the resistance of the water will always tend to diminish, and finally to destroy them. The form of the curve, when it becomes permanent, may be regarded as defining the *mean* position of its parts, when they have excursions on either side of this mean position. But in general they will be small in extent compared with the length of the curve, and we may assume that they will have little effect on the tension, for the same reason that in the catenary of a suspension bridge slightly oscillating, the tension will differ little from the statical tension if the motion of no point is abrupt.

The method by which Prof. Airy conducts his first investigation is very elegant. The form of the curve is referred to vertical and horizontal co-ordinates (y and x respectively) of which its lowest point is the origin. The velocity of paying out (n) is taken equal to that of the ship, and by geometrical considerations expressions are obtained for the absolute velocity of each point of the curve in terms of these co-ordinates and the velocity (n). The absolute horizontal acceleration of each element, multiplied by its mass, is equal to the difference of the horizontal components of the tensions at its two extremities, and the vertical acceleration is similarly equated to the difference of the vertical components of the two tensions minus the effect of gravity. Finally, it is shown that the curve is the common catenary, and the equation for its tension is of the same form as for the common catenary, except that for the tension of the catenary is substituted T—a, where T is the tension of the travelling curve, and a is proportional to n^2.

It is important to observe that in working out this problem Prof. Airy assumes that the curve is horizontal at its lowest point, because it must necessarily be so if it have the "smallest conceivable tension" there. It would have been well, however, to have considered the case where there is no tension at the bottom; for it is clear that that case is the more analogous with practice, since in general the paying out is faster than is absolutely necessary, and the cable lies loosely at the bottom of the sea. In that case, neglecting the friction of the bed of the sea, it is clear that there can be no tension at the bottom of the curve, for if there were the deposited cable would not be at rest. Moreover, in the case where the velocity of the ship and of paying out are equal, the original equations ought to be and are applicable to the case where the tension at the bottom of the curve is zero; for the deposited cable, if not attached at any point, may be considered free to move with the slightest force. If that be the case there will be a point at a short distance above the bed of the sea where T is equal to a. Then Prof. Airy's equation $(T-a)\frac{dx}{ds} = c$ becomes impossible, unless c is zero. In that case the curve becomes a vertical straight line. The case may also occur in which n is so great that T—a is always negative; in that case the curve is concave in the direction of the ship's motion. This will appear by differentiating the above equation; in the equation so obtained, since neither of the other differential coefficients involved is negative, $\frac{d^2x}{ds^2}$ is positive, or (if $\frac{dx}{ds}$ be zero) is zero also. The former result indicates a curve convex in the direction of the ship's motion, the latter a vertical straight line.

If the curve be concave in the direction of the ship's motion, it will follow, since $\frac{dx}{ds}$ is positive, that the curve is concave downwards. The concavity is therefore opposite in direction to that of the common catenary. This result may appear surprising, but it is at once explained by the consideration, that if the parts of the descending cable move in a curve convex upwards, their centrifugal force may more than counteract the tendency of gravity to deflect the curve downwards. The quantity a, the magnitude of which determines whether this will be the case, is the numerator of the fraction which measures the centrifugal force.

By eliminating successively $\frac{dT}{ds}$ and T from Prof. Airy's equations of rectilinear motion (article 6), the same results may be obtained as are obtained by normal and tangential resolution, namely (firstly) that T ÷ radius of curvature is equal to the sum or difference of the centrifugal force and the normal component of the weight; and, secondly, an equation from which by integrating we obtain $T = y + C$, where C is the tension at the lowest point. We therefore, while fully admitting the accuracy of Prof. Airy's mathematical investigation, venture to object to the mode in which he states in general language his conclusions from it. He says,

"Hence we obtain this singular result, that the form of the travelling curve is exactly the same as the common catenary; and that the tension at every point is exactly the same as at the corresponding point of a similar fixed catenary increased only by an absolute constant a, which depends only on the velocity with which the curve travels."

The former branch of this proposition seems to us deficient in generality: in the latter branch of it there is not, we submit, sufficient consideration to the manner in which the physical constants are to be obtained. They may depend on the resistance which the paying out apparatus offers to the descent of the cable, or on the forces to which the deposited part of the cable is subject. Take an instance of the latter case. The result just obtained, $T = y + C$, will hold when the deposited cable lies loose on the bed of the sea and is dragged along it. Then C is the force sufficient to overcome the friction of the deposited cable on the bed of the sea; so that the tension does *not* depend "on the velocity with which the curve travels." It is to be observed that though Prof. Airy has taken the velocity of paying out = the ship's velocity, his equations do not depend on that assumption, which is quite unnecessary. His conclusion, as well as the expression for tension just given, are independent of the ship's velocity.

We have considered the problem thus fully, though it differs greatly from the corresponding practical problem relating to the deposit of a cable in water, because we are satisfied that a right understanding of the former tends to remove much of the difficulty which besets the latter problem. We now proceed to the second investigation of the paper under review, of which the subject is the investigation of the form and tension of the cable-curve, when the fluid resistance is taken to vary directly as the velocity with which the body meets the water, and the tangential resistance to follow the same law and have the same coefficient of resistance. With respect to this assumption, Prof. Airy observes as follows:

"The frictional resistance of the water to the movement of the cable is so great as entirely to modify the circumstances of its deposit. Some time since, I had prepared an investigation of approximate character, on the supposition that the friction is small, when I learnt from good authority that in consequence of the slenderness of the Atlantic cable, and the lightness of its materials, its terminal velocity in falling through water would not much exceed three feet per second; and that the ship's velocity would probably be more than double the terminal velocity of the falling cable. It was impossible after this to

Digitized by Google

consider the resistance as a small quantity for which an approximation to the first order might suffice; and I then undertook the investigation in its fullest generality, as regarded the magnitude of the resisting force.

"In regard to the law of the resisting force, another difficulty presented itself. It is known that with large velocities the resistance varies nearly as the square of the velocity. This law offers almost insuperable difficulties to mathematical treatment, if we do not restrict ourselves closely by limitations as to the form and position of the curve. But with the term depending on the square of the velocity, there is combined a term depending on the simple power of the velocity; and with movements so slow as those of the cable in some parts, the term depending on the simple power may *perhaps* be the predominant term. I have therefore considered that no error of the least importance would be introduced by assuming the resistance generally to vary as the simple power of the velocity, provided that the coefficient be so adjusted that the resistance at or near the terminal falling velocity may be correct. As far as any error is sensible it will be of this kind, that for the lower velocities I have assumed a too great resistance; the general effect of this however will be neutralised, by assuming the ship's velocity to be a trifle greater than I have taken it in the numerical calculations.

"There is another difficulty peculiar to the circumstances of a moving cable. The cable moves longitudinally as well as laterally, and there is a considerable longitudinal friction as well as a lateral resistance. I have no data for determining the coefficient of this friction. A small error, however, in the coefficient is not important, for the longitudinal motion of the cable is always much less than its lateral motion. Under these circumstances I have considered that the law and coefficient of the longitudinal friction might, without practical error, be assumed to be the same as those of the lateral friction."

The laws of longitudinal or frictional resistance to the motion of bodies in water are included among the elaborate researches of Colonel Mark Beaufoy, published in his 'Nautical and Hydraulic Experiments' (4to, London, 1834). These experiments were numerous and long continued, and appear to have been conducted with great care. It was ascertained by trial what motive force was requisite to move at various uniform velocities a floating body or "conductor," first by itself, secondly when a long "friction plank" was attached so as to be immersed at a given depth in the water, and to move in the direction of its length. The difference of the motive forces at each velocity gave the resistance due to the friction of the plank, which in one set of experiments had a surface of 46, and in another set, of 50 square feet. From both sets of experiments it resulted that the friction varied nearly as the square of the velocity. In the following table the results are copied from Colonel Beaufoy's work (p. 487) of the number of pounds required to overcome at a velocity of 1, 2, 4, &c. feet per second the friction of 50 square feet, and we have added the corresponding friction per square foot.

Velocity in feet per second	1	2	4	6	8	10
Number of lb. friction on 50 square feet	·177	·710	2·72	6·23	10·97	16·96
Ditto on 1 square foot	·0035	·0142	·0544	·1246	·2194	·3392

It will be observed that by this table the resistance increases at first more rapidly than, and subsequently rather less rapidly than, the square of the velocity. This diversity may however arise from an error in the experiments; for it obviously must be difficult to observe with accuracy the small resistance at very low velocities. The resistance per square foot may be nearly represented, by taking it at the velocity of 1 foot per second to be between ·003 and ·004, and to vary as the square of the velocity. The Atlantic cable is about 5-8ths of an inch in diameter, and 2 inches in circumference. Hence the friction of 1 foot of its length, at the velocity 1 foot per second, is about ·0006 lb. Messrs. Longridge and Brooks, in their paper (p. 39) reviewed in our last number, take this friction to be ·00054778 lb. Now the resultant normal resistance to a cylinder of which the length is 1 foot, and the diameter in feet $=d$, and moving through the water in a direction perpendicular to its axis with the velocity 1 foot per second, is about $\cdot 8d$ lb.; or in the case of the Atlantic cable the coefficient of resistance = ·0417 lb., or is about seventy times greater than the coefficient of friction.

Prof. Airy, however, takes the two coefficients to be equal. We believe that the discrepancy between his assumed data, and the data obtained by experiment, and his excessive estimate of the effect of the fluid friction, most seriously affect the accuracy of his numerical results. In the passage which we have just quoted, he stated that he has learned, "from good authority, that in consequence of the slenderness of the Atlantic cable, and the lightness of its material, its terminal velocity in falling through water would not much exceed 3 feet per second; and that the ship's velocity would probably be more than double the terminal velocity of the falling cable." It seems to us that the information was either inaccurate or inaccurately understood. The terminal velocity here referred to is that velocity at which the fluid resistance is equal to the weight in water; that resistance being, according to the hypothesis, the same for the cable moving either laterally or longitudinally. But we have seen how different the lateral and longitudinal resistances are in amount.

This terminal velocity is defined (p. 4) by the equation $e = \frac{bn}{g'}$, where e is the proportion of the ship's speed to the terminal velocity, g' the weight in water of a unit of mass, and bn the fluid resistance to which it is subject at the velocity n. The quantity e is, in fact, the resistance acting at the velocity n on a unit of the cable divided by its weight. This will be very different according as we take the resistance to be the normal or tangential resistance. It is important to know what is the value of e in either case, because that quantity enters Prof. Airy's fundamental equations, and has a most important effect on the results obtained from them. First let the normal resistance be taken to be that which determines e. The velocity of the vessel in paying out the Atlantic cable in deep water was between 4 and 5 knots an hour; say 7 feet per second, which by the formula we have above given, would correspond to a resistance of rather more than 2 lb. on each foot of the length of the cable. The weight of the same portion of the cable is about $\frac{3}{10}$ lb.; so that the value of e is about $6\frac{2}{3}$. Secondly, let the tangential resistance be taken to be that which determines e. In this case the resistance at a velocity of 7 feet per second is about ·03 lb., and dividing by $\frac{3}{10}$ as before, we find $e = \cdot 1$ nearly. Now the value taken for e by Prof. Airy is 2. It seems then that this value is either greatly less or greatly more than the value which e has in practical cases.

There seems no ground for believing that, because the value of e assumed by Prof. Airy is between the two values which it practically has, according as either kind of resistance is taken into account, the errors in the result arising from taking it too large may counteract those arising from taking it too small. It would be impossible to elucidate this point without almost reprinting Prof. Airy's investigation, which is extremely elaborate. For the sake of our practical readers we are compelled to adopt a summary method of criticism, and test the results obtained by this complicated analysis by experience. At page 11 a table is given, from which we extract the following results:

Angle made by cable at leaving ship	8° 34′	11° 22′	14° 9′	16° 53′
Tension at the point of leaving ship	71·33	36·78	21·36	13·26
Stray length of suspended cable	·052	·070	·088	·107

The unit of measure is here the depth of the sea; so that, when the angle at leaving the ship is between 8° 34′ and 11° 22′, the tension is between 71 and 36 times the weight of a length of cable equal to the depth of the sea.

It was ascertained by actual measurement that the angle of the Atlantic cable as it left the ship in 2000 fathoms water was 9° or 10° with the horizon (see volume first above cited, page 67). A piece of the cable 2000 fathoms in length would weigh about 4000 lb., and as the tensile strength of the cable is about 9500 lb. it follows that the ultimate tension cannot be so much as three times the weight of 2000 fathoms of the cable. But if Prof. Airy's tabulated results were correct, the cable would be able to bear between 71 and 36 times that weight.

It is remarked that "a small change in the stray length makes a great change in the tension." What is here meant by "stray length" is the ratio of the difference between the length of the curve and its horizontal ordinate to the vertical ordinate, or $\frac{s-x}{y}$. This quantity is involved in the fundamental mechanical equations of the investigation under consideration, and is spoken

Digitized by Google

of as the quantity "necessary for the slope of the suspended cable." It may easily be seen that where the curvature is very small this stray length is nearly proportioned to the *gradient* of the curve or its angle of inclination to the horizon, where that angle is small; and for given depths the greater the "stray length" is the less in general will be that angle, and the greater the length of the suspended cable.

It appears to us that practically the tension does not depend on this "stray length"—at least, in any material degree. If the tangential friction of the fluid be neglected, the tension is always expressed by the equation $T=y+C$, where C is the tension at the lowest point of the curve. This equation is obtained immediately by the method of tangential resolution above referred to, and holds whatever be the law of normal resistance. That is, the tension at any point is equal to the weight of a length of a cable equal to the altitude of that point above the lowest point + the tension at the lowest point. This result is independent of the length of the suspended cable and of its velocities.

When the velocity of paying out is equal to or greater than that of the ship, the tangential velocity of each point of the cable relatively to the water may be easily shown to have a downward direction. Hence the friction of the water has an upward direction, and tends to diminish the tension as given by the above formula. But the coefficient of friction is so very small, that, without the length of the suspended cable be enormously great, the friction will have inconsiderable effect in diminishing the tension.

We have left to ourselves but little space for noticing the third subject discussed by Prof. Airy,—the form and tension of the curve when the normal and tangential resistances have different coefficients, and vary as the normal and tangential velocities respectively. The evidence of experiment is so strongly in favour of these laws, that it cannot but be regretted that Prof. Airy has not devoted to the third and more practical investigation some of the labour lavishly bestowed on the second, which we confess that we regard as little more than a mathematical abstraction. In the third investigation the general equations of the second order are obtained on the hypotheses last mentioned, but no attempt is made at their general solution. Doubtless the mathematical difficulties are very great, but seeing how much Prof. Airy can do with what he terms "repulsive" equations, we have no doubt that it was in his power to obtain useful results from the general equations just mentioned. Two results obtainable from them we will notice, as they are not adverted to in the paper before us. The one is an expression for the tension which when the friction is neglected agrees with the important law of the tension above stated; the other result is a remarkable expression for the radius of curvature of the cable-curve. The one result is obtained by eliminating T, and the other by eliminating $\frac{dT}{ds}$ between the first two equations of page 14.

A particular application of the equations is given in the case in which the cable curve is a straight line. The case in which this is possible was pointed out in the part of this review which appeared in our last number. We venture to think that this case may be investigated in a manner far more simple than is adopted in the paper before us. The angle of inclination of the straight line is at once obtained by resolving forces perpendicularly to it; and the tension by resolving forces along it. In this case there is no difficulty in estimating the effect of friction as the tangential velocity, and, therefore, the friction of a unit of length is everywhere the same. In this as in other parts of the paper the effect of friction is greatly over-estimated.

We have thus freely noticed Prof. Airy's paper, feeling that with respect to a subject of such importance as this, no investigation, however high the authority by which it is supported, can claim exemption from candid criticism. To the mathematical theory of the subject the Astronomer Royal has given a contribution scientifically valuable, but not available for practical purposes on account of its errors respecting physical data.

On the Practical Application of the Principles of Mechanics to Wrought-Iron Girder Work. By J. H. Latham, M.A., C.E., Fellow of Clare College, Cambridge. Macmillan, Cambridge. 1858. 8vo. pp. 282.

The rule of thumb is fast losing its old despotic sway in engineering; and few things, perhaps, have contributed more to its downfall than the introduction and successful use in many of our great works of wrought-iron. The uniformity of this material in its powers of resisting strains either tensile or compressive, in its elasticity, in its specific gravity, insures the mathematician a footing in all questions connected with its use, such as other materials do not offer.

The consequence might be foreseen; we have, on the one hand, many of our chief practical engineers generalising from practical experiments, and reducing their results to mathematical formulæ to be applied in all cases; while, on the other hand, we find mathematicians entering with great interest into practical matters, and so directing their theoretical speculations as to be of the greatest assistance on the most doubtful points of practice;—in a word, we find practical men becoming theoretical, and theoretical men becoming practical. Of the latter class the author of the work under our notice is an example. To the learning of the University of Cambridge he has added, as he states in his preface, considerable practical experience also, having been employed for some years by the late Mr. Rendel, and, since the death of the latter, by his sons, in the arrangement and allotment of the material in the bridges designed by those gentlemen.

Our author's application of his mathematical knowledge to the points of girder-work thus submitted to him, together with a variety of practical hints suggested to him by the results of his mathematical investigations, form the marrow of the book. The attempt made to present practical information under the form of a regular Cambridge book, wherein all the argument is based on exact definitions and axioms, is bold, and hence arise some curious inconsistencies in the book. For instance, in the first chapter we find definitions of everything—a rivet, a plate, a joint, &c.; not that we quarrel with the number or fulness of these, for although they may be useless to any one who has had any practical experience of iron-work, yet for beginners our doubt is rather whether they are sufficiently explanatory. Any fulness here, however, is more than matched by the deficiency further on, where we are hurried into the highest mathematical reasoning on the subject of deflection, without a word of definition of the same; we are neither told what it is, nor how it is measured,—whether by an angle or a straight line.

Again, the same attempt has led our author to lay down the following axioms, and on these his main propositions are founded:

"1. If a bridge be made strong enough to bear a load, defined in weight and position, in any particular method or way, then it will be able to bear it. The lightest bridge, however, will support the given load by the easiest method.

"2. But unless you can prove that the bridge can support the given load safely, by some one method or another, no reliance can be placed on the bridge."

It is the second clause of axiom 1, that we would notice more particularly. The "easiest method" is a vague term; for our part, we are forced to think that the clause means nothing more than that the lightest bridge is the bridge of least weight. If Mr. Latham means to say that the lightest bridge is also the best bridge, we at once answer that there is stiffness, durability, cheapness, beauty, and many other things to be considered besides lightness, before we have the best bridge.

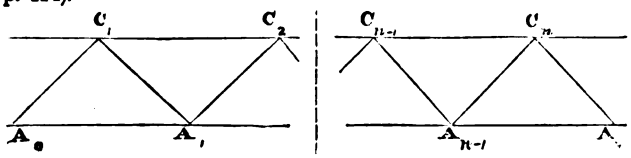
We admit that the investigations that follow refer entirely to lightness, and that viewed only in that light, they may be of the greatest use; but that by means of the above axiom their results can be made of any greater importance, we do most plainly deny. These, however, are but minor matters, and are rather necessary characteristics of the style adopted, than faults.

Before passing to the system of calculation for girders, we would give our warmest commendation to the very practical manner in which the author treats of joints; his aim in this matter, which has been most successfully attained, is thus stated: "My object has been, not to make the reader acquainted with a few empirical forms of joint, but to guide him, through all the ordinary resources available for rivetted joints, to skill in judging of their respective advantages." There is one omission, however, in this part of the work, which, though easily remedied, is too important to be passed over. We find definitions of *a rivet*, a rivet's efficiency, clear rules laid down for determining a *rivet's* effective strength in forming joints; but not a word do we find about *bolts*. Now it so happens that a rivet is treated throughout as a perfectly fitting bolt; consequently, all the reasoning that holds for one, holds for the other. It seems to us, therefore, that the rules laid down for rivets, with a view to bridges only, are of much wider application than, perhaps, even the author

Digitized by Google

supposed. We allude more especially to iron roofs and iron trusses of every kind; the rules are so clearly explained, and in a form so readily applicable to every requirement of shape or position, that they cannot but be of the greatest assistance to both engineers and architects in all designs of this nature.

We will now sketch as briefly as possible the method of calculation for wrought-iron bridges employed by Mr. Latham; premising that somewhat analogous investigations by Mr. Bow have been noticed in a review of his treatise on Beams (vol. xiv. p. 414).



Mr. Latham begins by investigating the case of a simple triangular girder, as shown in the figure, somewhat as follows:—Let W tons be the weight of the girder; (we omit to notice the load here, for the sake of brevity;) n, the number of triangles in the girder; α, the inclination of the bars to the horizontal members.

Supposing all the weight to be supported on the top of the girder, we have on each of the pins at $C_1, C_2 \ldots C_n$ a weight $\frac{W}{n}$.

First let us consider only the weight $\frac{W}{n}$ which comes on C_1. This weight, by the laws of the lever, must produce on the pier A_0 a pressure $= \frac{\text{horizontal distance of } C_1 \text{ from } B_0}{\text{span of girder}} \times \frac{W}{n}$

$$= \frac{n-\frac{1}{2}}{n} \cdot \frac{W}{n} = \frac{n-\frac{1}{2}}{n^2} \cdot W.$$

Now the vertical pressure on A_0 must be the pressure down A_0C_1 resolved vertically, or compression of $A_0C_1 \times \sin.\alpha = \frac{n-\frac{1}{2}}{n^2}.W$

$$\therefore \frac{n-\frac{1}{2}}{n^2} \cdot \frac{W}{\sin.\alpha} = \text{compression of } A_0C_1 \text{ due to weight } \frac{W}{n} \text{ on } C_1.$$

Similarly it may be shown that $\frac{n-\frac{3}{2}}{n^2} \cdot \frac{W}{\sin.\alpha} =$ compression of A_0C_1 due to weight $\frac{W}{n}$ on C_2, and so on for $\frac{W}{n}$ on $C_3, C_4 \ldots C_n$.

Hence total compression of $A_0C_1 = \frac{W}{n^2 \sin.\alpha} \overline{(n-\frac{1}{2}+n-\frac{3}{2}+\ldots+\frac{1}{2})}$

$$= \frac{W}{n^2 \sin.\alpha} \times \frac{n^2}{2} = \frac{W}{2 \sin.\alpha}.$$

In the same way it may be shown that

$$\text{Total compression on } A_1C_2 = \frac{W}{2 \sin.\alpha} \cdot \frac{n-2}{n}$$

$$\text{Total compression on } A_2C_3 = \frac{W}{2 \sin.\alpha} \cdot \frac{n-4}{n}$$

and so on for all the bars inclined upwards from left to right. Those inclined the other way, being similar in every respect, have the like strains.

Having thus obtained expressions for the strains on the bars, our author argues that the weight of all the bars as depending on the angle of inclination,

a the sum of the section of each bar $\times$ its length,

α the strain on each $\times$ the length of any one (since all are of equal length).

Adopting the usual analytical method for determining maxima and minima, he finds that the weight of the bars is a minimum when $\alpha =$ or a little greater than 45°, according as n is even or odd.

Next to find the weight of the top and bottom horizontal members:—We see that the strain on A_0A_1 will be equal to that on A_0C_1 resolved horizontally = strain on $A_0C_1 \times \cos.\alpha$,

$$\therefore \text{ tension on } A_0A_1 = \frac{W}{2 \sin.\alpha} \times \cos.\alpha = \frac{W}{2n \tan.\alpha} \times n$$

So compression on C_1C_2 = sum of compression on A_0C_1, and tension on C_1A_1 resolved horizontally

$$= \frac{W}{2n \tan.\alpha} \overline{(n+n-2)}$$

and tension on $A_1A_2 = \frac{W}{2n \tan.\alpha} (n+2n-2)$, and so on for C_2C_3, A_2A_3, &c.

Having thus found the strains brought upon every part of the girder, we can now consider the whole weight of it. This Mr. Latham does, and he shows that in cases where the depth of the girder is $\frac{1}{6}$ the length (as in bridges designed by Mr. C. H. Wyld), and also in cases where the depth is $\frac{1}{12}$ the length (as in designs by Messrs. M. and G. Rendel), the value of α, which gives a minimum weight for the girder, does not much exceed 45°; in fact the practical angle for the inclination of the bars pointed at by the results of the investigation is clearly 45°; and that angle our author adopts in all his after calculations. This proposition, briefly as we have stated it, will yet give the reader some idea of the reasoning on which the arithmetical computations that follow it are founded. Proceeding on a like basis with the above argument, they are nevertheless entirely independent, and are worked out in such a manner that they are open to any one who will have the patience to master them, even though he have no technical knowledge of mathematics.

The tables given in this part of the book, are applicable, not to the triangular girder only, but to the lattice, and in some sort to the plate-webbed girder also, these two last being considered as merely successive developments of the former. The lattice is but many systems of triangles, with equidistant parallel bars; the plate-web is only a lattice with contiguous bars.

The way in which Mr. Latham shows the passage from the lattice to the plate-web we shall state in his own language, reserving for the present the consideration of the validity of his method.

"We may pass in theory from a lattice to a plate-web as follows: If we supposed a lattice-girder, with its bars at a horizontal distance equal to that between the rivets which attach the plate-web to the booms (4" for instance), we should *then* be able—*first*, to calculate closely the maximum strains brought upon each rivet by the two lattice-bars attached by it to the boom, and consequently the resultant of those strains.

"If we *next* suppose every bar of this lattice, which slopes (say) down from left to right, to be widened out to $4'' \times \frac{1}{\sqrt{2}}$ (*i.e.* about 3") width, and made proportionately thin; then the sides of two contiguous bars will be in contact; and we may further imagine them joined so as to form a web-plate. They will form a plate strained by parallel strains down from left to right, at an angle of 45° with the horizon; the strains increasing towards the pier and diminishing towards the centre. We may *now* suppose the other lattice bars, which crossed the former at right angles, to be removed, for the strains thus superimposed on the new web-plate will be at right angles to, and therefore will not interfere with those already acting on it; and it only remains to make the thickness of the plate, and the diameter of each rivet connecting it to the boom, so large as to have together a bearing surface sufficient to pass the resultant of the strains which, as above, would have been brought upon each rivet in the lattice-girder, from the new web-plate to the rivet, to be by it transferred to the boom.

"This reasoning leads us to notice the following peculiarities in which a plate-girder differs from a lattice-girder; the reason of them is manifest:

"1. The theoretical weight of a plate-web, that is, the net section required by theory, is only half that required in a lattice-girder.

"2. While in a plate you can hardly hope to secure a bearing on its rivets of above $\frac{1}{4}$ or $\frac{5}{16}$ of its gross section along the line of rivets, in a lattice, on the other hand, a bearing can as readily be obtained equivalent to from $\frac{1}{2}$ or $\frac{3}{4}$ (in the ties), to from $\frac{3}{4}$ to the whole (in struts) of the section of each bar."

"3. In a plate-girder, since the web forms a continuous rigid vertical communication between the top and bottom booms, it is therefore, theoretically immaterial whether the load be placed on the top or bottom boom, or any part of the web.

"4. There is an extra weight in the plate-web due to covers and stiffeners; and there is more rivetting.

"5. The plate-web resists curvature of the booms, incomparably more than the lattice-web. If the plate were already taxed to its

Digitized by Google

full power as a supporting web, the curvature caused by deflection would probably split it; but (see 2) the plate-web is generally four times above its required strength."

We ought to add that an independent and more practical method is given afterwards for the plate-webbed girder.

Having said thus much of Mr. Latham's system, in which he professes to exhibit the application of mechanical theory to girder-work in *as simple forms* as possible, we would suggest the following proof of the strains on the bars of the triangular girder, which may be compared with that given above; we use the same figure and notation as before.

The pressure at each pier, and therefore at A_0, is $\frac{W}{2}$, this must be transmitted wholly by strain on bar A_0C_1, which is a strain of compression. Hence compression of A_0C_1 *vertically* is $\frac{W}{2}$, and therefore total compression of A_0C_1 is $\frac{W}{2 \sin. \alpha}$.

Consider now the equilibrium of pivot C_1.—The *vertical* forces acting are, pressure of A_0C_1 upwards; weight on C_1, $\frac{W}{n}$ downwards; and *vertical* tension of A_1C_1, which must act downwards.

Hence tension of A_1C_1 *vertically* $= \frac{W}{2} - \frac{W}{n} = W\frac{n-2}{2n}$

$$\text{Total tension of } A_1C_1 = \frac{W}{2 \sin. \alpha} \frac{n-2}{n}$$

Again, from equilibrium of A_1

$$\text{Total compression of } A_1C_2 = \frac{W}{2 \sin. \alpha} \frac{n-2}{n}$$

And similarly, total compression of $A_2C_3 = \frac{W}{2 \sin. \alpha} \frac{n-4}{n}$

and so on for all the bars.

This, we think, is not only a simplification of this one proposition, but might also be used as a key to a simpler method of numerical computation. True it is, that as we begin with the end bars, which have the greatest strain. we should have to use subtraction in our calculations, which Mr. Latham objects to for practical use, as being more liable to error than addition,—but still, the rapidity with which the strain on the first bar is arrived at would seem sufficient to counterbalance that objection. At all events, the one method might be safely recommended as a check upon the other.

In the above remarks we have noticed one part of the book only. We pass over for the present the investigation of the laws of Deflection, and a comparison of the Suspension Bridge, Suspended Girder and Hanging Girder, in regard to their respective weights and merits. The questions involved in these, requiring as they do considerable theoretical knowledge, are of the highest interest to all professional men; and we hope at some future time to be able to enter into them with the care which they deserve. Meanwhile we cannot part with our author without offering him our best thanks for the really valuable practical book which he has given to the world.

Designs for Factory, Furnace, and other Tall Chimney Shafts. By R. RAWLINSON, Esq., C.E. London: Weale. 1858.

There is no student of natural scenery who can have failed to observe how much of the character of a landscape is due to what is technically called the sky line, and how that by it may be only a slight diversion from a given point, that character will often become utterly changed. Yet there is no one who will say that in all the "freaks" of nature there is not really either a perfect consistency or a cause for the reverse, which at once reconciles us to the fact. Great is the contrast between the wild impatient forms of the Langdale Pikes and the placid wavings of the South Downs; between the towering steeps of Dovedale or Cheddar and the miniature beauties of the Isle of Wight; and, until man intrudes his civilised notions, all is satisfactory and delightful: but let him be permitted to range at will, dotting the panorama where and with what he chooses, and the spell is broken, nature's repose is disturbed, and the pleasant scene delights no more. What outrageous eyesores in this point of view have been deliberately planned and carried out in such ungainly forms as the Britannia and Saltash bridges, or the multitudes of villas which have sprung up (in the Undercliff of the Isle of Wight for instance) spotting and spoiling an ever-changing landscape, which but a few years since had irresistible charms. So in our cities and towns, while it is the boasted prerogative of Englishmen that they "must have liberty, withal as large a charter as the winds," this independence of action is a sad stumbling-block to anything like unanimity of feeling and effort, and thus the perverse irregularity of the buildings, public and private, which line our streets necessarily entails a loss of massive grandeur, without ensuring with the variety a compensating picturesqueness. We are not disposed to argue for that rigid monotony of plan which has dictated the setting out of many American cities, and which is carried out even to the names and numbers in their streets; but some such watchful guardianship should be exercised as would prevent the absurdities we have been hinting at; in this matter we may take a lesson from our neighbours, for "they manage these things better in France."

We are however being led too much away from the present object we have in view, which is, to introduce to our readers a handsome volume just issued from the press, and which bears practically on the question with which we started. It is notorious that those towering erections, factory chimneys, are as a rule uniformly hideous in appearance; whereas it is easy to conceive that there would be no great difficulty, by bestowing a little attention on the subject, to render them rather pleasing than repulsive in character. In ordinary cases (our large manufacturing towns for instance) the numbers which are upreared on a comparatively small area is a necessary evil; it is therefore the more desirable that their existence should be made as tolerable as circumstances and variety will admit; while in exceptional cases where a lofty erection has the presumption to assume to be the prominent feature in a scene, it is inexcusable if the utmost pains be not bestowed to render it in form, colour, and details such as shall satisfy the eye that it is at least an allowable, if not agreeable object. In the work before us, Mr. Rawlinson, an engineer of some experience, shows a variety of methods in which the subject may be met, and we are bound to say that his suggestions appear to be in the main excellent. The designs are numerous, and illustrated by perspective sketches; but several plates at the end of the book are exclusively constructional, and will be found worthy of study, as combining the science of the subject with artistic management.

The plates are 22 in number, and illustrate designs which all partake more or less of the campanile type; in plan some are square, others octagonal, or clustered circles, and most of them have an upper stage of a lighter character and more varied outline. We find suggestions for ordinary chimney and ventilating shafts (detached),—for a clock-tower and ventilating shaft in brick-work, terra cotta cornices, and cast-iron roofs, with a central staircase of cast-iron steps;—for water towers and engine houses in various materials;—for a pumping establishment for town water-works,—and for the engine-house, chimney, and water-tower erected at Worthing. Bricks of two colours were used here, and Caen stone dressings. The roof of the chimney is of cast-iron (open), the tank is also of cast-iron, and the roof over is of red tile. The tower is 40 feet square, the tank 12 feet deep, and will contain 110,000 gallons of water. There is a central staircase of cast-iron passing up the tower and through the tank.

To give an idea of the recommendations of the author we quote the following remarks:

"The lofty towers of Italy, and the minarets of the East, are, for the most part, constructed with bricks and mortar, and neither the one nor the other is better, if so good as the modern architect may have at his command. The proportion of brick to mortar in the foreign structures differs, however, most materially from modern practice.

"The bricks of Italy and of the East are generally very thin in proportion to area of bed—9 inches square by inch, or at the most 1½ inch in thickness. These bricks, or tiles, are frequently set or bedded in mortar as thickly spread as the brick; so that there is almost as much mortar as brick. The permanence of the work is in a great measure dependent on this liberal use of hard-setting, tough mortar. The tornado's sweep, and the earthquake's shock, have alike failed to overthrow these slender and lofty piles; though many times they must have shaken, vibrated, and bent under the furious effects of the contending elements, and tremblings of the earth. The elasticity and tenacity of the mortar has, probably, alone preserved the structures from sudden

Digitized by Google

overthrow. It is a modern practice to stint the use of mortar. Specifications generally set forth that a bed of mortar shall not exceed ⅛ of an inch. It will be a new clause—but not any less useful one—if at times it is specified that a bed of mortar shall not be less in thickness than half or quarter of an inch. In tall chimneys or towers the mortar should be of the best quality; it should be ground by horse or steam power, and should be used liberally.

"With thin bricks and thick beds of mortar the Italians used iron bolts for bond, and some of the Eastern minarets have poles of timber enclosed vertically in them. Timber cannot, of course, be used in tall chimneys, but hoop-iron for bond is well known to the profession, and its aid is highly desirable for many purposes. Rods or bolts of wrought-iron to give vertical tie may be used; but all tall structures should depend on the cohesion and gravity of the materials for stability and permanence, rather than on iron or other aids.

"Tall chimneys have elements of destruction to contend with which are absent in Italian tower and eastern minaret; namely, great heat, and gases which may affect and destroy both bricks and mortar. The only remedy against these elements will be, so to design and construct the chimney as to have an inner lining of the flue, which may be cut out, taken away, and be replaced without endangering the structure. A space, or air-chamber, betwixt the true shaft and lining, will be of great service in preserving the whole.

"Towers and minarets have, for the most part, internal stairs, or means of access up them. Our largest and tallest chimneys may easily have means of access provided, as, also, means for erecting temporary scaffolding for examination and repairs, should repairs be required. This hint will, I doubt not, be sufficient. An architect or an engineer should provide for all contingencies, and not build a tower or chimney 300 feet in height, and remove his scaffolding, without having considered the means of future examination and repairs. A recess with step and handirons, and putlock holes at regular stages, properly formed for easy use, may furnish means within the shaft. Openings through the shaft may form part of the design; such openings having the character of sunk spaces, the formed space being filled in, but affording means for the removal of the filling without fracturing the main work of the shaft. All tall chimneys or towers should have proper electric conductors secured in the best manner.

"Colour and ornament may be used in tall chimneys: contrast of colour may be made to produce ornament. The common bricks of almost any district may be sorted so as to produce contrast in tint or "tone"—red, and yellow or "cream colour." This tint of the bricks may be preserved and heightened by using mortar of the same tone or tint. Furnace ashes and lime will produce a dark mortar; pounded red brick or red tile mixed with lime will give a red tone to mortar; and cheap mineral colours may be added to mortar for pointing. The colour of mortar is sadly neglected, as, generally, the same white lime and sand are used for all tones of colour in bricks, and not unfrequently white putty-mortar is used for jointing the reddest, as well as the lightest coloured bricks;—the light-coloured work having harmony of breadth and keeping,—the red brick portion being frittered and broken up by the contrast betwixt bricks and beds and joints.

"In the designs now submitted, vertical lines are for the most part used, where existing structures (tall chimneys) invariably batter. There is great beauty in a vertical line.

"Most of the designs are for detached structures; and it is desirable that tall chimneys should stand detached, on their own base. A special foundation should then be prepared; and the chimney will not depend on any building for support, nor injure nor be injured by vibration, nor by partial settlement in the foundations. The vertical form adopted almost throughout, may be objected to as offering a larger area for wind to act upon: the wind will not, however, injure a sound structure standing on a good foundation. The force of wind in our greatest storms rarely reaches 30lb. on the square foot; the gravity of any chimney is much greater than this. Eastern minarets and Italian towers stand not only storms of wind, but also shocks of earthquakes.

"In no case are quoins shown, either in plinth or in shaft, and their adoption is repudiated to the uttermost. Whatever material is used, must set in course with the bricks, or must form entire courses round plinth or shaft. This rule should have no exception, but should apply from foundation to summit. An external band of stone may be backed up with brick to receive the action of fire or heat; but, in such case, the stone should set in bond with some exact number of courses of bricks, so that the whole may be grouted and flushed into solidity.

"In arranging cornices and roofs on chimneys, it may be necessary to use iron bond and iron cramps. In such cases, great care must be taken so to use the metal as to run the least risk from contraction or expansion. It is practicable to combine iron with stone and brickwork, so as to ensure strength and safety; but the combination must not be lightly undertaken nor be carelessly made.

"Several modern tall chimneys have fallen in consequence of over-weighting at the top. A tall chimney, top-heavy, is easily made to sway or rock in a storm of wind, until the vibrations increase beyond the power of stability. Tall chimneys should diminish in thickness and in weight of material from base to summit: the top-finishing, in all cases, being as light as is compatible with security and endurance."

The best brick structures of England and of the Continent are deserving of more attention, as also the buildings in which alternate courses of bricks, stone, or marbles are used. Why should modern architects shrink from using colour more freely to obviate monotony, provided the eye and mind are gratified? The difficulties which once existed with regard to the use of bricks are now happily removed, and the results may be seen in many of the new buildings of London and elsewhere. Manufacturers are ready to carry out still further improvements, the great desideratum being facility of application, and the next novelty of effect. Any new forms of brick must work in bond or in course with common bricks, and be practicable not only to the maker, but also to the bricklayer. The dimensions of any new forms in brick or terra-cotta should also not exceed the easy manipulation of the material from the clay state to the finished and burned brick or tile; and the form in all cases should be one of strength, both before use and after it has been set in any building. The form and dimensions of a common brick are excellent; there is a union of strength, facility for handling, and adaptability to work any useful bond. There are many fine old brick buildings in England in which strings, cornices and chimneys are admirably wrought in the bricks of the period, and endure in almost pristine perfection when stone has crumbled to decay.

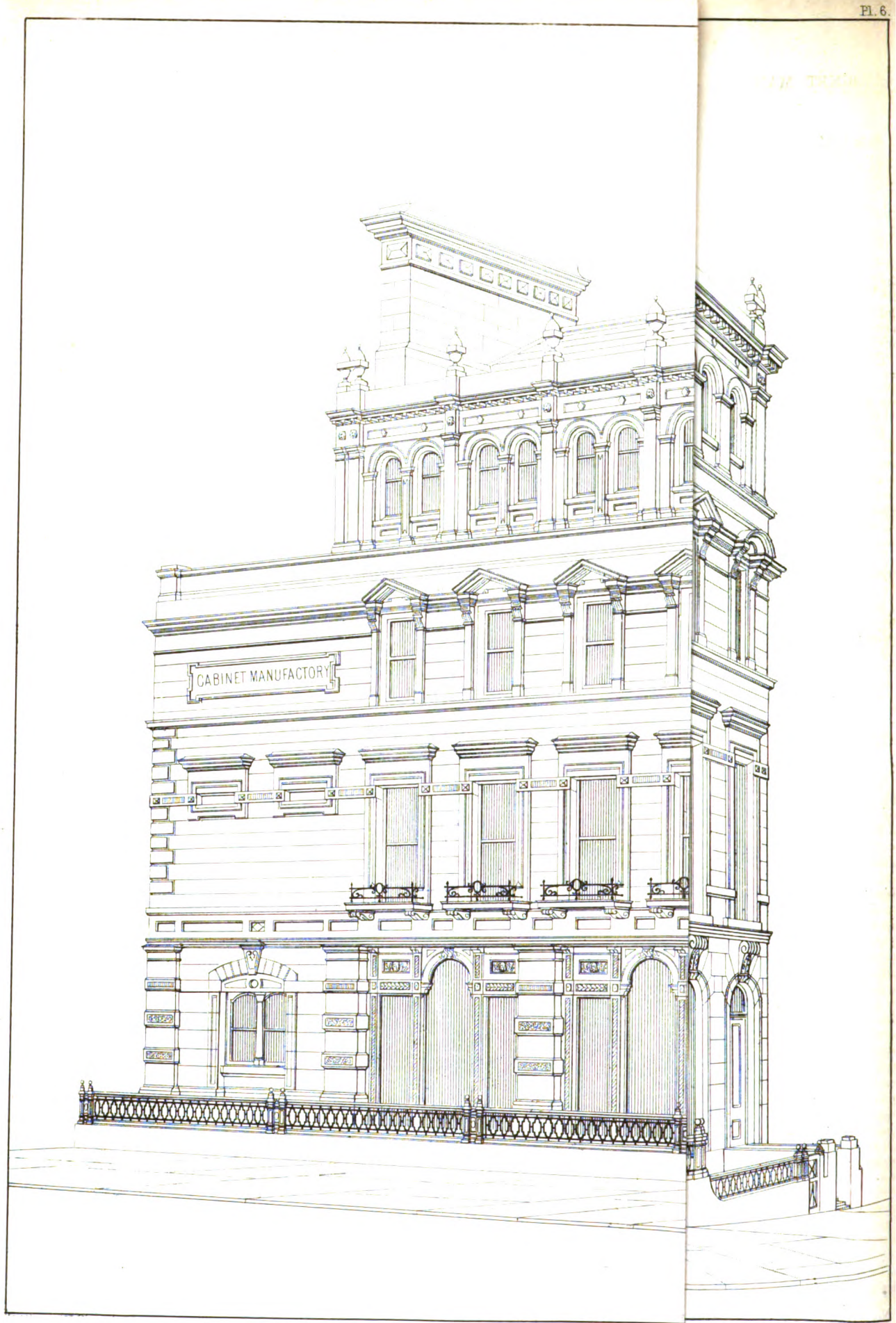
Drinking Fountains in Ancient Times and Abroad.—Public drinking fountains have always been considered in the East as a most essential part of social convenience. In ancient Rome public drinking fountains were plentiful, even on the public road, for the use of the cattle driven to the capital from great distances. A recent traveller, who made a pedestrian tour from Nuremberg to Regeansburg, states that in one of the now most secluded parts of this road-way of the middle ages, he found amongst brambles and wild shrubs the remains of one of the finest architecturally ornamented drinking fountains he ever met with. But it seems that the providing of a drinking place was once considered as one of the *manorial duties* which the landlord owed to his vassals and tenants. In the Imperial Palace (*Burg*) of Vienna, there is a well cut in the rock to a great depth, and yielding the best water within the whole compass of the city. At that well, in one of the yards of the Imperial Residence, iron ladles have been hung up from time immemorial for the public availing themselves of this superior beverage. The newly erected fountain, near the *Stubenthor*, entirely of marble and bronze, is one of the finest and chastest ornaments of the Austrian Capital.—[We shall feel exceedingly obliged to any of our readers or countrymen in Vienna, who will furnish us with a sketch of the above fountain.—Ed.]

TO CORRESPONDENTS.

We have received from Mr. Charles Henry Brooks a reply to the review, published in our last number, of the memoir by Mr. James Atkinson Longridge and him "On Submerging Telegraphic Cables." As the memoir was a joint production, each author may claim a right to reply to the review, but it would be inconvenient to occupy our pages with two replies and two rejoinders,—twice discussing the same questions. The reply ought therefore to be a joint production. Besides, we are not without hopes that discussion between the two authors may tend to considerably narrow the issues between them and us. They shall be fairly heard in a reply on which they are agreed. As the review was not written without due consideration, and the subject is difficult, the reply ought to be maturely considered. The authors cannot therefore be prejudiced by the delay which the course we propose will occasion.

Digitized by Google

Digitized by Google



J.R. Jobbins.

Mr. S. ABBOTT'S SHO

Digitized by Google

CABINET MANUFACTORY AND SHOW ROOMS, LIVERPOOL.

(With an Engraving.)

It is to the spirited enterprise of private individuals that the town of Liverpool is enabled to boast of so many palatial looking edifices devoted to the purposes of trade. The architectural rivalry displayed in each shop or warehouse has in every town greatly contributed towards giving character and tone to a street or locality. When such competition involves the complete rebuilding of extensive premises and street-fronts, the architectural character of a town is felt and recognised, and when such erections have been carried out conformably with the taste, and under the immediate direction of an architect, they become not only indications of the tradesman's individual progress, but an important link in the great chain of improvement,—guiding the public to a correct appreciation of those architectural beauties necessary to enrich every great city.

From a number of such buildings recently erected in Liverpool we may select one possessing such qualities, serving to illustrate our preceding remarks, viz., the premises belonging to Mr. S. Abbott, cabinet manufacturer, of which we give a perspective view.

This building is situate on the west side of an open space at the confluence of Great George-street, Duke-street, Berry-street, and Nelson-street, having a frontage to Nelson-street 120 feet, and to Duke-street 30 feet long. It contains show-rooms for carpets, furniture, and paper-hanging (the largest being 52 feet by 28 feet), offices and packing rooms, all on the ground floor; handsome staircases lead to show-rooms of a similar size, to the height of two floors above, the upper floor being used as a store-room.

The south-end contains workshops, as also the basement under principal show-rooms. The north-end is occupied by the proprietor as a place of residence. The front is faced (with the exception of portico, cills, &c. to large openings, which are of Yorkshire stone) with Portland cement. The entire front is surrounded by low palisading in iron of an ornamental design, resting on a stone plinth. The total cost of building complete was £2756. It was erected from the designs of Mr. Henry Sumners, architect, Liverpool.

THE COMPETITION DESIGNS FOR THE NEW TABERNACLE FOR THE REV. MR. SPURGEON.

The great fact of the past month, next to the parliamentary discussion on the New Foreign Office, is the competition for Mr. Spurgeon's Chapel; the designs for which have been on view at Rea's Repository, close to the intended site of the new building, at the Elephant and Castle. The whole affair has awakened considerable curiosity, not merely attributable to the object itself and the distinguished prime-mover in it, but also to the peculiar terms of the scheme furnished to competitors in reference to the preparation of their drawings, and the adjudication of premiums. On these points it will be sufficient to remark that the present Surrey Music Hall was recommended as a basis both as to system of arrangement, and on account of its excellent acoustic properties;—that the stipulated accommodation was for 4000 persons, or 3000 seated and 1000 in "standing room;"—that there was to be a basement story providing a large lecture-hall for 800 persons, six vestries, with other offices, and a baptistery in connection with the floor above. The amount of expenditure contemplated was stated to be about 16,000*l.*, inclusive of the architect's percentage, and each competitor was requested to state what terms he was disposed to affix in this matter. Moreover, the designs were to be sent in under mottoes, but the names of the authors to be communicated (in confidence, of course) to the committee; and the awarding of the first and third premiums to be entrusted to ballot-voting among the competitors themselves, the committee reserving to themselves the disposal of the second premium. The several premiums were 50*l.*, 30*l.*, and 20*l.*, but that of the successful man to be merged in his commission, provided his design be carried out. One very singular clause in the instructions was, that "Gothic" designs would be altogether rejected,—the reason for this it is not easy to surmise.

In response to this appeal there were received some sixty-two designs, swelling into about 450 drawings, these happily were so disposed in the spacious "subscription room" above named, that each could be examined with the utmost readiness and convenience; a circumstance, it is needless to remark, greatly facilitating the arriving at the wished-for result. Yet, withal, it is a matter of regret that there was so little deserving of actual scrutiny; it being, we believe, almost unanimously agreed that, with scarcely an exception, so mediocre, not to say unsatisfactory, an exhibition has not for a long time been seen. The expression which pervades the majority of the designs is one of a decidedly civic or domestic character:—it would not be difficult to imagine that we are contemplating some town hall, assembly rooms, or less inviting subject, trickily decked out. The peculiarities of the case in a great measure favour this impression, especially when the flank elevations are in view, for the arrangements for the accommodation necessitating, in almost every instance, two galleries, and occasionally three, their existence is evidenced externally by corresponding tiers of windows. Then again, there is no exclusive or conventional means of indicating the precise purpose of this class of building, since the usual ecclesiastical symbols and accessories are eschewed, to a great extent, in dissenting chapels. In regard to the predominant architectural *style*, unquestionably the prevailing characteristic was an almost utter abnegation of the recognized rules. Gothic, we have remarked, was forbidden, but a tendency to Gothic features, such as the pointed arch and minor details, are occasionally observable. The nearest approach to these, with any consistency, is in a few designs which are founded on a Byzantine type, while the majority are decidedly of Roman or Palladian character, with here and there one of a nondescript kind, or of a professedly constructional form, in which metal is usually the all-important material. With all our partiality for the legitimate developments of practical art, we are prepared to endorse but few of such suggestions as here meet our view.

With regard to *plan*, the ordinary form proposed for the chapel is that of a parallelogram; in many cases the internal angles are canted or rounded off, in others the shape may be described as consisting of two semicircles lengthened, so as to make a kind of ellipse, while in some the internal space forms an exact square. The position of the pulpit, too, is variously shown; but owing to the size of the area required, it is generally at about one-third of the length down the chapel. That such a position, however favourable in many respects, would not be acoustically good has been repeatedly proved, and we are therefore not surprised at noticing that in several designs the pulpit is placed at nearly the extreme end, and before a kind of apse, constructed so as to throw out and distribute the voice, but both plans have their recommendations and the reverse. In front and below the pulpit we usually find the baptistery, a large open chamber communicating with the vestries: some of the designs, however, conceal it wholly by floors and moveable seats to slide over it, except when the rite of baptism is to be administered. In one case forethought is carried to so great an extent that the passages of communication are shown and described as to be laid flush with the ordinary floor, with perforated framework or grating "to receive the drippings!" The seats are generally arranged to suit a direct view of the preacher, and they therefore often radiate, instead of being throughout in strictly parallel lines. This remark applies also to some of the gallery plans, which are in this way most whimsically devised. The ceilings are almost universally adapted or closely imitated from that of the Surrey Music Hall; some few of these have the addition of dormer lights all round, which, however pleasing as an architectural embellishment, would tend very much to interrupt the free current of voice, and be therefore objectionable. The same applies to the lantern lights which are observable in some of the drawings.

A most important item in the plan is the means provided for the exits and the staircases, and it is one which is dwelt upon in every report we happened to look over; it is evident, too, that it is a point which has been carefully considered in the majority of cases, though with unequal success. It is not enough merely to provide width of stairs, but winders should be as rigidly as possible avoided, as also the inconvenience arising from intercepting crowds of people from different doors. This is a point which appears to have been hardly calculated enough, and there are comparatively few plans which provide, beyond the external lobby, any large space, open or sheltered, in which the throng of people may conveniently disperse. On many of the points we have thus enumerated it would be easy to enlarge, but it is time that we particularise a few of the leading designs.

Digitized by Google

And first, of course, the premiated designs, viz., with the mottoes 'Quod erat Facierum,' and 'Alpha,' the former proving to be by Mr. E. C. Robins, of London, and the latter by Mr. W. Hill, of Leeds. We are not disposed for a moment to question the propriety of this selection, especially in the case of the latter, yet, on the face of things, that there were more attractive designs will be readily admitted. Bearing in mind however the stipulations as to cost, style of getting up drawings, &c., and acting stringently (as no doubt they did) upon these conditions the number of designs available for selection from would be reduced to comparatively few.

The aspect of Mr. Robins' design may be characterised as of a town-hall kind; certainly by no means suggestive of a chapel, and some of the features which would have been useful as stamping the purpose of the building, the author makes a merit of disguising. We allude more especially to the staircases, of which there are four principal ones, one in each angle. These are contrived so as not to intrude on the area of the chapel, and thus cause obstructions to sound; so far so good, but from their form (an irregular ellipse) they will surely prove very inconvenient, involving as they do an unbroken succession of winders. Externally, there are no doors or any indications whatever of the existence of these staircases: the windows, which would naturally be accommodated to the raking of the steps, are ranged with those of the flanks, and the whole is thoroughly incorporated with the bulk of the mass, exhibiting only rounded corners, in themselves less satisfactory as a finish than a marked angle. Another serious defect in this plan appears to be, insufficient provision for ingress and egress. The doorways under the principal front are miserably small, the side lobbies by no means adequate to the requirements, and the centre one scarcely deserves the name;—possibly these objections can hereafter be rectified. The plan of the chapel itself is an elongated circle, and it has been very carefully arranged, though the position assigned to the pulpit is not quite satisfactory. The chief feature outside is an entrance portico, in the Roman Doric style, with coupled columns, the whole evincing much care both in the study and delineation. The estimated cost is £16,469.

The second premium remains as yet unbestowed, but the third premiated design claims our next attention. This is decidedly more chapel-like, in appearance than the one we have just noticed, and bears throughout a thoroughly practicable air. Like the former it has staircases at each of the four angles, and a portico at the end. In this case we have six columns, and the Corinthian order is employed instead of the Doric. The fault in this design is one observable in very many others, and indeed is almost unavoidable under the circumstances; we mean, too great a loftiness for its span. What else can be expected when the side elevation exhibits four tiers of windows? The plan is a parallelogram. The estimated cost is as follows:—carcase only, £11,000; finished complete, £14,450. The architect's commission to be 5 per cent. While mentioning the latter we may remark, that the request of the committee on this subject has met with various replies. Many of the competitors stipulate for the usual percentage, which is assuredly none too much when an architect's duties are conscientiously performed; others profess themselves willing to accept a less remuneration, and a few compromise matters by expressing a readiness to make a donation to the funds out of the usual commission.

A design which deservedly attracted much attention had the motto 'Ebenezer.' The principal front has an upper and lower portico of rusticated columns, coupled, and is marked at the angles with well studied towers surmounted by cupolas. The roof is curved, following the prescribed model. The general plan is simple and good, and the whole is estimated at, carcase, £12,000; finished complete, £15,000.

Perhaps the next set of drawings which we should notice are those submitted under the motto of 'The Temple,' and accompanied by printed specification and report. In respect of painstaking and elaboration these were equal to any in the room, but it is at once evident, that properly to carry out such a design would require a much larger outlay than is now contemplated.

'The Propagation of the Faith' is the title of an extensive set, which has many recommendations. As in the first-selected design the four staircases are quite exclusive of the area of the chapel, while both they and the portico arrangements are much better contrived. It must be evident how great an advantage is secured when the means of comfortably leaving a crowded place are well thought of; and this is evidently the case in the plan before us. "The building is also set back about 50 feet, allowing space for carriages to set down, and for persons on foot to congregate before doors are opened." With such a frontage there would be less inconvenience and interruption by street-noises, and the general elevation would gain much in dignity. It is a wonder that this idea has not been more frequently worked out. The plan itself presents some novelties, ingenious and otherwise, and there is merit in the sections. The architectural details of the elevations appear, however, to be somewhat faulty; no estimate is appended, but its cost would probably exceed the prescribed sum.

'Deo volente' has a peculiar plan, based on that of St. Sophia at Constantinople; consisting of segmental transepts and apse, the area in front of the pulpit being a square. There are two galleries, and additional ones in the transepts and at the west end. This is a better arrangement for seeing than hearing, while externally we lose that decision of outline which so large a building ought to possess. It appears to us also that though there is considerable ability shewn in the boldly designed tower and other features, the whole has too much the look of a country villa residence to be suitable. Estimates, carcase £9900; completed, £16,000.

'Hope' has a very fair principal elevation, but in no particular style. The roof is curved, and proposed to be covered with corrugated iron. The plan has as usual four staircases, each being 5 feet wide; the seat accommodation is 3010, and the "standing room" will admit of 1600 more, reckoning each person as occupying 2 ft. 6 in. superficial. The estimated costs, £9000 and £15,000.

The unintelligible motto, 'Phawbh,' distinguishes a peculiar set of drawings. The plan is a very lengthy parallelogram, the pulpit being placed against one of the long sides, with a recess behind containing the organ;—the only arrangement of the kind we have noticed. The exterior is heavy in design, and by no means prepossessing; the ceiling is elliptical, in one span, and some of its panels serve for ventilation. The exits, it may be observed, are well planned. Estimate, £15,000.

'Fiat Justitia' is very faulty in design, and has an enormous pediment in front, unrelieved by the slightest enrichment. The hideous skylights visible on the slope of the roof are enough to condemn all. The staircases are at the pulpit end, arranged in the form of transepts.

'Byzantine' has but two staircases at the angles, and is otherwise open to much objectionable remark. The elevations are wretched.

Much better is the design a little further on, distinguished by *a triangle enclosed in a circle*. The exterior is simple, and on the arcuated type, while the interior is well devised. There are two rows of galleries, and the pillars to the different stories are respectively of the Doric, Ionic, and Corinthian styles.

'He that Soweth plenteously shall Reap plenteously' is in plan nearly a square. There is very little architecturally to attract attention. The whole has too much of the "residential" character, despite of the poverty of some of the windows. Style, Italian, and estimates £11,000 and £15,000.

'Meliora' is also an Italian design, with some recommendatory features, the exterior having a more chapel-like appearance than most. The plan is, however, confused. Estimates, £7520 and £16,120.

'Gloria in Excelsis' has the true Music Hall roof, but its general appearance reminds one of a conservatory.

'Faber suæ Fortunæ' will not be indebted for his motto to such designs as the one here submitted. Nothing scarcely could be worse, unless it be its neighbour, 'Amity.'

'Religio' is an unpretending design in the Lombardic style. The windows are detached and absurdly small, giving the side elevation a truly prison look. The seats are curved on plan.

'Conor' is an *attempt* truly, and nothing more.

'Via ad Cœlum' has been aptly supposed to be borrowed from the Kremlin, though the author describes the style as "one that admits of the free use of modern appliances and improvements," adding, that "every tendency to Gothic has been avoided." It is all pilaster and window, with four uniform octagonal towers, and needle-like spires at the angles. It could not be executed for the money.

'Pro Propaganda Fide' is an Italian design, not without some good points as regards architectural composition, but utterly unsuited to the present case.

Digitized by Google

'Nomen alibi' has a roof in three segmental spans. The exterior is showy but tasteless; there is nevertheless some contrivance in connection with the entrances under the porticoes, which are partly recessed and partly projecting.

'Dignissimo' has not a very attractive exterior: the ceiling is honey-combed, and has a range of skylights in the centre. The seats in the chapel are placed in part obliquely, as in some other designs.

'Faith' has a plan better arranged than most: the proportion of length to width is 2½ squares nearly, and the open space at the entrances must be noticed as a good feature. The architectural portion is rather ambitious, and would probably prove over the mark in cost.

'Metropolitan' has a radiating plan, with sloping floors. The galleries are supported on classical columns. The general treatment of the elevations is heavy. Estimate, £15,454, including £500 for Caen stone dressings, but not for the statues shown on the perspective.

'Unity' is square on plan, 84 ft. 6 in. each way; the ceiling is gathered over into a circle, and is surmounted by a dome. The architecture is Byzantine, and feebly designed; the estimated cost £9500 and £18,200.

Let the House be Builded' is a very homely design, in brick; the plan resembles that of the Surrey Music Hall. 'Mea Gloria Fides' (on the same screen) has seats on the ground floor slightly curved, and externally has a handsome semicircular Corinthian portico.

'M' has its leading ideas borrowed from the Free-trade Hall at Manchester, and the design is on the whole satisfactory; abundant means of exit are contrived. The accommodation is for 3206 persons, and the estimate is put down at £16,000.

'In Good Faith' has some clever points, but they are not altogether happily worked out. The area of the chapel is 137 feet by 102 ft. 6 in., with a clear passage of 10 feet at the sides. Four spacious "crush" staircases are provided.

'Honi soit qui mal y pense' is in the Lombardo-eclectic style (at least it is so described). Considerable care has been bestowed in the getting up of the drawings, and it is evident that they have also occasioned much study. A prominent feature externally is a covered way, arched, and extending across the whole entrance front; this would be an expensive though convenient addition, but cost seems to have been little regarded in preparing this design. The author "regrets that the committee should have lowered themselves by requiring architects to state the commission they require on outlay."

'K' is a design which evinces considerable talent, but injudiciously applied. The style is Italian, simply treated.

'AR—O—ES' marks an unfinished set, not devoid of ingenuity and good taste.

'The Tabernacle' is chiefly noticeable for the bold conception of its interior: its sound practicability may, however, be questioned. "Four columns carry arches of 30 feet span, and a wooden ceiling; and the galleries, circular on plan, are carried independently by iron columns."

'Non nobis Domine' is a reproduction of the Surrey Hall, translated into a Basilican medium. The cupolas too closely resemble the pepper-boxes of our National Gallery to be satisfactory.

'In Domino Confido' has too much of a domestic look. There are four staircases at the angles, crowned with high truncated roofs. The plan is a parallelogram, and well arranged.

'A1 for £4000' is chapel-looking, so far as simplicity is concerned, there being only few architectural features; these, however, are unobjectionable.

'Omega' is a very feeble production. The windows have rusticated jambs, and do not harmonise with other parts of the design. Internally there is a dome 44 feet square at the base, and 100 feet high, carried on four pair of slender cast-iron columns.

'AZ' has another variation of the Music Hall roof, adapted to a square area of 10,558 feet super. The cupolas outside over the staircases are undeniably ugly.

'Lex' is, on the whole, a plain good-looking design (if we except the skylights), and is well arranged. The plan is a parallelogram, and the exterior has a bold portico and two turrets. The accommodation is for 3080 persons and 1000 "standing." Estimate, £15,000.

'Templa quam Dilecta' is very bold and effective, at the same time costly. It has a six-column Doric portico,—well designed cupolas at the angles,—and a roof of the Music Hall kind, but playfully broken by a series of small dormers, though these, it is probable, would interfere with the transmission of sound. The available area is 150 feet by 103. The pulpit arrangements are very *flighty*. The ceiling good, proposed to be carried on four large arches, rising from single columns,—a venturesome suggestion, we take the liberty of remarking.

'Press Forward' must be enumerated among the whimsical contributions to this exhibition. It is one of those on the Crystal Palace type, the roofs being constructed on the ridge-and-furrow principle. Estimate, £31,000!

'Ubique' is another metallic design, worthy of the "iron age." The authors seriously urge an investigation of its claims; but after bestowing on it a due share of attention, we are at a loss to discover the pre-eminent recommendations it is said to possess. Accommodation for 6000 persons.

'Spes' again introduces us to the Surrey Music Hall, but has some pleasing differences. It is one of the best of those founded on that type. Estimate, £15,500: and the author asks for his commission and measuring 8 per cent.

'Fortuna Sequatur' has a rectangular plan, 137 ft. 6 in. by 82 ft. 6 in. The architectural features classic, of a very ordinary description.

'Fides Salutis Via' presents a boldly treated mass, with, in general, rusticated parts.

All Above Ground.' One of the many curious mottoes, but distinguishing a design of considerable merit. The plan of the chapel is octagonal.

'Hit or Miss' proposes a showy Corinthian portico as a frontispiece, to be built in cement! Need we pursue the scheme any further?

'Finem Respice.' This set of drawings is stated to be based on the "new" style, *i.e.*, we presume, a sixth classic order, judging from the shafts of the portico, which are octagonal instead of circular, and set angularly. The general effect of this portico, nevertheless, is that of the ordinary Corinthian kind. The roof does not appear to grow happily behind the side walls, and several other portions are capable of great modifications and improvements. Estimate, £16,500.

We have thus commented freely on the designs for this chapel, and by way of conclusion can only repeat the observation with which we started, that the exigencies of the case have been far from met, and that the architectural standard has not been, in our opinion, fairly acted up to by any one of the numerous competitors whose works we have been examining.

ON SUBMARINE TELEGRAPHS.

By Homersham Cox, M.A., Barrister at Law.

Engineering in its great and rapid progress in modern times has attracted the attention of mathematicians to many problems of the highest scientific interest, and all capable of more or less complete mathematical solution. The number of these problems is continually increasing, and among the most interesting and most important of them is the investigation of the mechanical circumstances of the submergence of submarine telegraph cables.

The subjects which it is here proposed to discuss are of great practical importance, viz., the *form* which the descending cable assumes, and the *tension* to which it is subject under conditions such as occur in practice.

On both these subjects very elaborate investigations have been published, including those published by the Institution of Civil Engineers last year, and the Paper of Prof. Airy, reviewed in the last number of this *Journal*. From the very difficult analysis contained in those papers it might be inferred that the investigation in question is one which a person without considerable mathematical powers could not expect to comprehend. I am not without hope of being able to show in the course of this Paper that, so far at least as the more practically important aspects of the subject are concerned, it may be rendered intelligible without a great demand on the mathematical powers of the reader, and that even the non-mathematical reader may by moderate attention assure himself of the validity of the general principles involved in the investigation. I may state at once that the simplifications which it is the object of this Paper to present arise partly from the question being confined to the case most analogous to practice, viz., where the tension of the cable on the

Digitized by Google

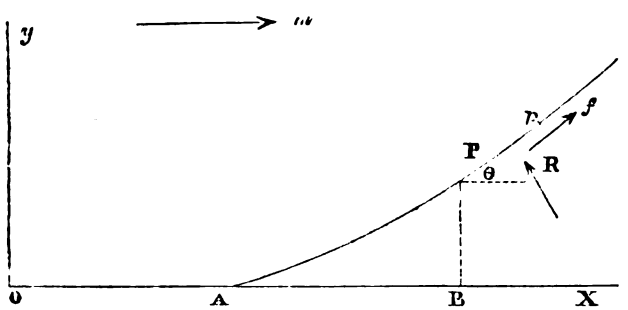
bed of the sea is inconsiderable, and partly because the method of resolving forces, known as the method of Tangential and Normal Resolutions, is here adopted.

When the submergence of the cable commences it is doubtless subject to *oscillatory* motion, and throughout the process of submergence is liable to be swayed by the action of the waves and the pitching of the vessel: variations of the depth of the sea are another cause disturbing the motion of descent of the cable. These disturbing causes may however, for many practical purposes, be neglected. With regard, in the first place, to what may be called the regular oscillations of the cable—that is those which would occur if the ship were sailing uniformly over a smooth sea of uniform depth:—these oscillations are continually reduced and ultimately destroyed by the resistance of the fluid, for the same reason that the oscillations of a pendulum, vibrating in a resisting medium, are continually reduced and ultimately destroyed. With regard to the direct action of the waves on the cable it is to be observed that that action extends only to a depth which is a very small fraction of the extreme depths of the sea, which it is most important to consider. I believe also that, on account of the very oblique direction of the cable in the water and other causes, the effect of the pitching of the vessel is much less important than is commonly imagined. The investigation of this effect however, as well of the effect of variations of the depth of the sea, cannot be well considered until the problem of submergence under circumstances of perfect regularity has been investigated. The effects of disturbing causes in modifying the results of that investigation may be treated independently.

It will therefore be here assumed that the ship moves uniformly without oscillation, that the depth of the sea and the velocity of the paying-out apparatus are constant, and that the line of the descending cable is invariable in form, and advances uniformly with the ship, and lies in the vertical plane passing through the ship's axis.

Before entering on the mechanical part of the subject it will be desirable to state the geometrical relations involved in it. Let Ox be the horizontal line in the bed of the sea and plane of the cable; A the point where the cable meets the bed of the sea at

Fig. 1.



the time t; O a fixed point from which A has moved during the same time; Pp an element of the length of the cable inclined to the horizontal, at the angle θ. Let the horizontal arrow indicate the direction of the ship's motion, and let m be the velocity of the ship, and n that with which the cable is payed out from the ship.

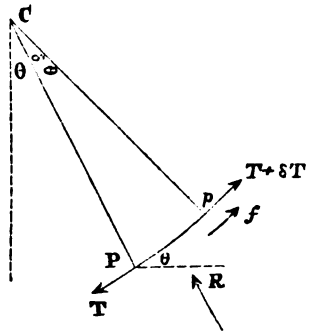
Let AP$=s$; P$p=\delta s$; OB$=x'$; AB$=x$; PB$=y$; $\sin\theta=\frac{dy}{ds}$; $\cos\theta=\frac{dx}{ds}$; $\frac{ds}{dt}=-n$.

The velocity with which Pp meets the water normally is the component of m resolved perpendicularly to Pp, or $m\sin\theta$. The velocity with which Pp passes tangentially through the water is due partly to the velocity of paying out and partly to the horizontal progress of the line Ap. The tangential velocity due to the former is n; the tangential velocity due to the latter is m resolved along Pp, or $m\cos\theta$. The difference between these two, or $n-m\cos\theta$, is the tangential velocity of the element Pp relatively to the water ... ... (1)

These two expressions will be used in measuring the resistances tangential and normal to the cable.

The velocity of paying out is assumed to be greater than the velocity of the ship, so that $n-m\cos\theta$ is positive, and the friction of the water acts on the cable in an upward direction. Draw the normals CP, Cp (fig. 2) to the element Pp. C is ultimately the centre of curvature of the curve for the point P. CP is inclined to the vertical at the angle θ, at which Pp is inclined to the horizontal. Let the angle PCp be $\delta\theta$; CP$=\rho$; T the tension at p; T$+\delta$T the tension at P; Rδs the normal, $f\delta s$ the tangential or frictional resistance of the water on the element δs.

Fig. 2.



First suppose there is no velocity (m) due to the progress of the vessel, but that the only motion is that of paying out. Then the element Pp may be considered as a particle moving uniformly with the velocity n in the path APp. Therefore, by known principles of the dynamics of a particle, the tangential components of the forces acting on Pp may be equated to zero, and the normal components may be equated to what is called the centrifugal force.

Let the weight of the element δs *in water* be $Mg\delta s$. The component of this force resolved tangentially is $Mg\delta s\sin\theta=Mg\delta y$.

The equation of tangential forces is therefore

$$\delta T+f\delta s = Mg\delta y.$$

Hence integrating, and assuming the tension to be zero at the bed of the sea, we have

$$T=Mgy-f\int\delta s \quad ... \quad ... \quad ... \quad (2)$$

whatever be the form of APp. The assumption that there is no tension at the bed of the sea will be reconsidered presently.

Again, resolving forces along CP, and putting the centrifugal force equal to $M\delta sn^2\div\rho$, we have

$$M\delta sn^2\div\rho=(T+\delta T)\sin\delta\theta-Mg\delta s\cos\theta+R\delta s.$$

Now in the limit $\rho\delta\theta=\delta s$; $\sin\delta\theta=\delta\theta$. Therefore, dividing all the terms of the equation by δs we have in the limit

$$Mn^2\div\rho = T\div\rho-Mg\cos\theta+R;$$

or

$$(Mn^2-T)\frac{d\theta}{ds}=R-Mg\cos\theta \quad ... \quad ... \quad (3)$$

Substituting in this equation the value of T found by (2), we have a differential equation to the line of the cable.

The above results have been obtained on the assumption that there is no horizontal motion; but they will be unaltered if that motion exist, if we suppose the fluid resistances to be the same in both cases.

This conclusion is an immediate deduction from D'Alembert's theorem, by which what are called the "effective" forces of a system statically balance the impressed forces. The equations expressing this equilibrium are the same whether the velocity m be or be not impressed. For we assume the impressed or actual forces external to the system (the weight and fluid resistances) to be the same in both cases; and the "effective" forces are hypothetical forces which measure the accelerations of the different parts of the system: these however are unaltered, for the velocities only, and not the accelerations, are varied by the velocity m being supposed to be impressed. Consequently the equations of motion are the same whether the velocity m be supposed to exist or not.

It may be useful to refer to some illustrations of this principle. A piece of mechanism in motion will have certain strains due to its motion; but it is clear that those strains will not be affected by conveying the apparatus in a vessel which glides uniformly in a straight course in smooth water. Similarly a ball thrown in the air by a person on land will describe the same curve as if similarly thrown in the cabin of the vessel, the resistance of the air being supposed to be the same in both cases.

It may also be observed that the above results (2) and (3) are obtained directly without reference to the case in which m is zero.

OA (fig. 1)$=mt$, OB$=x+mt$. Also $\frac{dx}{dt}$ is clearly equal to $m-n\cos\theta=m-n\frac{dx}{ds}$; and $\frac{ds}{dt}=-n$. Therefore

$$\frac{d^2x'}{dt^2}=\frac{d^2x}{dt^2}=n^2\frac{d^2x}{ds^2}.$$ Similarly, $\frac{d^2y}{dt^2}=n^2\frac{d^2y}{ds^2}$

Digitized by Google

Hence the equation of horizontal and vertical motion are respectively

$$M ds\, n^2 \frac{d^2y}{ds^2} = d(T\cos\theta) - Mg\delta s + f ds\cos\theta + R ds\sin\theta$$

$$M ds\, n^2 \frac{d^2x}{ds^2} = d(T\sin\theta) + f ds\sin\theta - R ds\cos\theta.$$

These equations agree with those given by Prof. Airy in article 24 of his paper in the *Philosophical Magazine* for July 1858. But neither the following nor any other method of solving them appear to have been hitherto published.

Multiplying the first equation by $\cos\theta$ and the second by $\sin\theta$, and subtracting, we obtain the equation from which (2) is obtained above. Again, multiplying the first by $\sin\theta$ and the second by $\cos\theta$, and subtracting, we obtain equation (3), (remembering that

$$\left.\frac{d^2x}{ds^2}\cdot\frac{dx}{ds} + \frac{d^2y}{ds^2}\cdot\frac{dy}{ds} = 0\,;\ \frac{d^2y}{ds^2}\cdot\frac{dx}{ds} - \frac{d^2x}{ds^2}\cdot\frac{dy}{ds} = \frac{d\theta}{ds}\right)$$

The equations (2) and (3) therefore apply when the ship moves with the velocity m.

In (2) it has been supposed that the tension at the bed of the sea is zero. This assumption is made because the cable is payed out at a greater velocity than that at which the ship sails. Consequently the cable is deposited at the bottom of the sea in coils or "puckers." For it is clear that if while the ship has sailed (say) a hundred miles, over a sea of given depth, a hundred and twenty miles of cable have been deposited on the bed of the sea, that cable cannot have been deposited in a *taut* line. Therefore (neglecting the friction of the bed of the sea), if the least tension were applied to this deposited cable it would tend to straighten it. We are justified therefore in assuming that the tension at the bottom of the sea is zero.

Hence we obtain from (2) the important result, that if the friction of the water on the descending cable be neglected, the tension at any point is equal to *the weight in water of a length of the cable equal to the altitude of that point above the bed of the sea.*

Substituting from (2) in (3) we have for the differential equation to the line of the descending cable

$$(Mn^2 - Mgy + f\int f ds)\frac{d\theta}{ds} = R - Mg\cos\theta \ldots \quad \ldots \quad (4)$$

We will in the first place neglect the friction f, and the velocity n. The last equation then becomes

$$-Mgy\frac{d\theta}{ds} = R - Mg\cos\theta,$$

which represents the form of a flexible line *suspended* from the ship, and not descending through the water, but drawn through it by the ship.

By the ordinary hypothesis of fluid resistance, which will be reconsidered presently, the resistance varies as the square of the relative velocity of the fluid and solid. Hence it appears from (1) that $R = Am^2\sin^2\theta$, where A is a constant depending on experimental data. Put $Mg = 2c\,.\,Am^2$ and $\cos\theta = q$. Then the last equation becomes

$$-2cy\frac{d\theta}{ds} = 1 - q^2 - 2cq.$$

Differentiating $q = \cos\theta$, we get

$$\frac{dq}{ds} = -\sin\theta\,.\,\frac{d\theta}{ds} \text{ whence } \frac{dq}{dy} = -\frac{d\theta}{ds}$$

Therefore from the above equation

$$-2cy\frac{dq}{dy} = q^2 + 2cq - 1 = (q+c)^2 - (1+c^2)$$

Let $1+c^2 = b^2$. Then

$$-\frac{dy}{2cy} = \frac{dq}{(q+c)^2 - b^2} \ldots (5); \quad \text{or } \frac{1}{2c}\log\frac{a}{y} = \frac{1}{2b}\log\frac{q+c-b}{q+c+b} \ldots (6)$$

where a is the constant of integration. From the last equation

$$\left(\frac{a}{y}\right)^{\frac{b}{c}} = \frac{q+c-b}{q+c+b} \ldots (7) \quad \therefore \frac{y^{\frac{b}{c}} - a^{\frac{b}{c}}}{y^{\frac{b}{c}}} = \frac{2b}{q+c+b} \quad \ldots (8)$$

The above is a general solution involving an arbitrary constant a; but in the case before us we find that, q being restricted in value by its geometrical meaning (the cosine of an angle) we are compelled to select a particular value of the integral. Since q is always finite, and since the denominator of the fraction on the second side of (7) is always positive, it follows that that fraction is always finite. In order that the first side of (7) may also be finite when $y=0$, we must have $a=0$. Therefore equation (8) becomes

$$1 = \frac{2b}{q+c+b} \text{ or } q = b - c = \sqrt{(1+c^2)} - c \ldots \quad \ldots \quad (9)$$

This is the equation to a straight line. It may be easily found that the value of q given by (9) is the same as would be obtained by making the second side of the equation which follows equation (4) zero; in other words, the normal force R is statically equal to the effect of gravity resolved normally.

The above result has been obtained on the supposition that n and f in equation (4) are neglected; but the result is the same if n and f are taken into account. This we shall proceed to show by an entirely independent method, which, besides its generality with respect to n and f, is more general than the preceding method with respect to the law of the normal resistance. This has been hitherto assumed to vary as the square of the normal velocity with which the fluid meets the cable; but the law in question is found by experiment not to be strictly accurate, for it has been ascertained that a solid which moves in a given direction through water, always at the same velocity, but with different inclinations to the direction of motion, does not meet with resistances which vary exactly as the squares of the angles of inclination (see *Encyclopædia Britannica* article Hydrodynamics). The actual law of resistance is uncertain; but this much is obvious, that if different parts of the cable are differently inclined to the horizon those parts which are more nearly vertical, being more directly opposed to the fluid, suffer greater normal resistance than those parts which move through the fluid more obliquely. Consequently, the greater $\frac{dy}{ds}$ is, the greater is R; and this conclusion holds whether the law of resistance be taken to be that of the square or any other power of the velocity.

If in equation (3) $\cos\theta$ be put $= \frac{dx}{ds}$, and $\sin\theta = \frac{dy}{ds}$, and therefore $\cos\theta\frac{d\theta}{ds} = \frac{d^2y}{ds^2}$, we get

$$(T - Mn^2)\frac{d^2y}{ds^2} = (Mg\frac{dx}{ds} - R)\frac{dx}{ds} \quad \ldots \quad \ldots \quad (10)$$

From equation (2) it appears that T increases with the altitude above the bed of the sea, for the effect of friction to diminish the tension is always much smaller than the effect of gravity to increase it.

It is quite clear that the direction of the cable is never vertical; for if it were so at any point the tension at that point would not have any effect to draw the lower part of the cable through the water: and it is certain that the horizontal effect of friction (which is small) would not suffice to overcome the horizontal effect of the normal resistance. Therefore $\frac{dx}{ds}$ is never zero or negative. Hence in (10) for the value of y which makes $T = Mn^2$ (since the first side of that equation is then clearly zero) the quantity in the parenthesis on the second side must be zero also.

If (10) represent a straight line, $\frac{d^2y}{ds^2}$ is zero. If $\frac{d^2y}{ds^2}$ be not zero, let it first be a positive quantity for values of y greater than that which it has at the point where $T - Mn^2$ is zero. Since $\frac{d^2y}{ds^2}$ is positive, $\frac{dy}{ds}$ increases from that point. Therefore R increases, and $\frac{dx}{ds}$ diminishes. Hence $Mg\frac{dx}{ds} - R$ is negative; and the second side of (10) is negative. So ought also the first side of the equation to be negative. But since T has also increased, the first side of (10) is positive; or the assumption that $\frac{d^2y}{ds^2}$ is positive, leads to an absurdity.

Secondly, let $\frac{d^2y}{ds^2}$ be negative for points above that at which $Mg\frac{dx}{ds} - R$ is zero. Then $\frac{dy}{ds}$ diminishes, R diminishes, $\frac{dx}{ds}$

Digitized by Google

increases, and $Mg\frac{dx}{ds}-R$ becomes positive. But at the same time, since $T-Mn^2$ is positive, the first side becomes negative; or this hypothesis also leads to an absurd conclusion.

The only possible hypothesis then, is that $\frac{d^2y}{ds^2}$ is zero always, or that the equation (10) represents a straight line.

It follows that *when the velocity of paying out, and the velocity of the ship and the depth of the water are constant, the descending cable assumes the form of a straight line, inclined at such an angle that the normal resistance at every point is equal and opposite to the effect of the weight resolved perpendicularly to the line.*

The reasoning on which the above conclusion depends, requires that there shall be value of y for which the first side of equation (10) shall be zero. This will always be the case if the tension be zero at the bed of the sea. If however there be tension there, and its amount be greater than Mn^2, there will be no point for which the first side of (10) is zero, and consequently the reasoning by which the conclusion is obtained is not applicable. In all other cases the equation (9) represents the inclination of the cable.

It appears from equation (9) that the inclination of the straight line of the cable does not depend on the frictional resistance, nor the depth nor the velocity of paying out, but merely on the quantity c, which is half the ratio of $Mg : Am^2$, or of the weight of a unit of length to the normal resistance on that unit at the velocity m.

The resultant resistance of water normal to the surface of a cylinder, a foot in length, where the velocity perpendicular to the axis is m feet per second, and the diameter d feet, appears to be about $\cdot 8dm^2$. In the case of the Atlantic telegraph cable d is $\frac{5}{8}$ inch $=\frac{5}{96}$ foot. Also the velocity of the ship when in deep water was from 4 to 5 knots per hour, *i.e.*, from 6·7 to 8·4 feet per second. The weight of 1 foot of the length of the cable in water is about ·3 lb. Hence we have $\cdot 8m^2=56$ at 5 knots an hour, and $=36$ at 4 knots an hour. Therefore $\cdot 8dm^2=2{\cdot}91$ in the former case, and 1·87 in the latter case. Therefore $Mg \div Am^2$, or $2c=\cdot 16$ in the latter case, and $=\cdot 103$ in the former.

If $q=\cos\alpha$, the equation (9) gives $q=\cdot 92$ in the latter case, and $=\cdot 95$ in the former case nearly; or the angle of the inclination of the cable to the horizon is between 23 and 18 degrees.

Mr. James Bodie, master R.N., who accompanied the expedition on which the Agamemnon was employed for laying the Atlantic telegraph, states in his 'Observations on Telegraphic Cables,' (Devonport, 1857) that he observed the angle which the cable made with the surface of the sea, at nearly any rate of speed of the ship, to be from 11° to 22°. Mr. Webb, in his paper read at the Institution of Civil Engineers, 23 Feb. 1858, states that he observed the angle to be 9° or 10° in a depth of 2000 fathoms, but he does not state the velocity at which the ship moved when the observation was made.

The length of the oblique line is the depth × cosec α = the depth multiplied by 2·56 or 3·23, according as the inclination is 23 or 18 degrees. Again, the length of this oblique line multiplied by $\sin\alpha$ (*i.e.*, by ·39 or ·309) = the depth. Therefore the tension is from $\frac{4}{10}$ to $\frac{3}{10}$ of the weight of the oblique line, if the effect of friction be neglected.

We may now take into account the effect of the friction of the water in diminishing the tension. The friction on 1 foot of the length of the Atlantic cable moving through water with a tangential velocity of 1 foot per second is about ·0006 lb. (see last number of this *Journal*, p. 64). Now the tangential velocity is $n-m\cos\theta$. Take n the velocity of paying out to be $5\frac{1}{2}$ knots an hour, or 9·3 feet per second, which was nearly the highest velocity at which the Atlantic cable was payed out. Take $m=8{\cdot}4$ feet per second and $\cos\theta=\cdot 92$, as found above. Then the tangential velocity is about 1·5 feet per second; and the friction on 1 foot of the cable (being as the square of this velocity) is about ·0013 lb., or (since the cable weighs ·3 lb. to the foot) the friction is about ·004 of the weight of the cable, or about 1 to $1\frac{1}{3}$ per cent. of the tension it sustains at its summit if there be no friction.

The inclination of the cable as above computed, is between the degrees of inclination observed by different observers. I am disposed to think that the smaller of the observed angles was nearest in value to the actual angle of inclination to the horizon of the Atlantic telegraph when the speed of the vessel was great. The hypothesis on which the angle has been here computed are, firstly, that when a cylinder moves perpendicularly to its axis through the water, the resistance to motion is the square of the velocity multiplied by a constant; secondly, that when the cylinder moves obliquely, the resistance perpendicular to its axis is the same constant multiplied by the square of the velocity resolved in the same direction. Experiment seems to show that the first hypothesis is quite close enough to the truth for our present purpose, but that the resistance to oblique motion is greater than the second hypothesis would give. That being so, the angle of inclination to the horizon is less than that above computed

It is however important to remark that the three principal conclusions of this paper do not depend on a particular assumption of the law of resistance; but hold when *any probable* law is assumed. These three conclusions it may be worth while to recapitulate. They are:

1. That the tension at any point (neglecting friction of the water) is the same as the statical tension would be if the cable hung vertically.
2. That the effect of friction under ordinary circumstances is to reduce the statical tension little more than one per cent.
3. That the form of the cable is a straight line, so inclined that the weight and normal resistance are at every point statically balanced.

Lincoln's Inn, Feb. 1859.

NEW CHURCH, PENTREVOELAS, CARNARVONSHIRE.

A NEW church for this village, arising chiefly through private munificence, was recently consecrated by the Bishop of St. Asaph. It is a simple unpretending structure, but well suited in every respect to the locality. The plan consists of a nave, chancel, and south transept; there are no aisles, but a small vestry is attached to the chancel on its north side. Preparations have been made for the erection of a south porch, but at present there is no protection of the kind. The walling is of local materials, roughly dressed, and the buttresses are of low plinth-like character, reaching but partially up the walls. They are introduced, moreover, at the main angles of the building only. The windows are usually lancets, coupled so as almost to look like the ordinary two-light arrangement, and the plinth is formed by a very bold set-off, rising directly from the ground. At the west end, and on the south front of the transept, are two long single-light windows, while at the east end is a triplet; these, although severe in their character, are nevertheless quite in keeping with the rest of the design. The bell turret is of stone, and at the west end, its thickness being partially carried by a row of stone corbels. It is gable-roofed, and has openings for two bells. The side profile has string-mouldings and buttresses running through the full thickness of the wall. The chancel arch is of large span, the roofs, both of church and chancel, are of rafters framed polygonally. The accommodation is for about 200 persons.

MELBOURNE CHURCH, DERBYSHIRE.

MR. G. G. Scott has been called in to advise and report upon the restoration of this very curious ancient church, which dates back to a period little short of the Norman conquest. Its plan is a remarkable one, both in point of arrangement and the massive symmetry observable throughout. Though its western façade has never, probably, been completed, its eastern tri-apsidal termination is almost obliterated, its high-pitched roofs are lowered, and several other features are grievously mutilated, it still retains, particularly within, very much of its nobleness of character, and if restored, though but in a partial degree, would exhibit them to far greater advantage. The church consists of a nave of five bays, with a western narthex and side towers, there is also a central tower with transeptal additions, and a very narrow chancel. Although the whole span of the church, including the aisles, is but 46 feet, the walls are no less than 5 feet thick, and all the rest is in proportion. The great characteristics of the interior are, the narthex before mentioned, and the central lantern, yet both are at present lost to it. It is of course urged that these should be immediately restored.

The masonry in general is considered to need a good deal of

Digitized by Google

reparation, besides the removal of the whitewash, for in addition to reckless mutilation, it has apparently suffered at some early period from fire. The architect was desirous of replacing the present roofs by others of a high pitch and more suitable design, but, as funds are restricted, this is (for the present at least) not contemplated. By the general rearrangement now proposed, accommodation is provided for 670 persons, besides that which would be available in the very wide central passage, which is purposely left for chairs when occasion requires. Over the narthex is an ancient stone gallery, which is intended to be appropriated for children.

The general estimates are as follows:—

For the reparations and restoration of the fabric, including the restoration of the western doorway, the timber ceiling over the lantern, roofing in the western towers, &c. ...	£1000
The refitting, reflooring, &c. (in deal)	500

THE NEW FOREIGN OFFICE.

This subject has in various ways, but more particularly in the House of Commons, been brought of late somewhat prominently under public notice. Mr. Tite, who never loses an opportunity of opposing the Gothic revival, seems determined not to let the grass grow under his feet during the present session of parliament. As early, therefore, as the eleventh of last month he opened his campaign against the appointment of Mr. Scott to the new government buildings. After a hasty outline of the history of the competition, in which he omitted any allusion to the most striking features, or the abandonment of its results by the late government; and after admitting that the evidence of Mr. Burn and the assessors had naturally led to the setting aside of the first prizemen, Messrs. Coe and Hofland,—he stated that Messrs. Banks and Barry, to whom had been awarded the second premium, felt aggrieved at the preference being given to Mr. Scott (he having obtained the third place by the decision of the judges). He then proceeded to a rather unsparing censure of the style of the design itself, charging against it the stereotyped catalogue of defects with which it has been so long the fashion to assail it, though, in his hearing when sitting on the select committee, these had been disproved, not only by the evidence of Mr. Scott himself, but by that of various witnesses whose personal bias might have led them in the opposite direction. Mr. Tite was followed by the ex-premier, who, in a string of *ad captandum* jokes, endeavoured not only to throw discredit upon the style, but to reduce *ad absurdum* the reasons given by Lord John Manners for his appointment of Mr. Scott. A day or two later an earnestly-expressed letter from the latter gentleman appeared in the "Times," pointing out how entirely the charges brought against both his design and its style had been refuted in the evidence given at the before-named committee, and appealing urgently to members of the House of Commons against the attack made upon him.

On the following Friday, however, the discussion was revived by Sir Benjamin Hall, who seems as if indulging the weakness of feeling annoyed that the scheme on which he had so greatly and so justly plumed himself should fall into the hands of his successor. Lord John Manners, however, met his remarks vigorously, showing that Sir B. Hall had taken the utmost pains when in office to secure to himself the fullest freedom of choice between the premiated designs;—that his Government had not only availed themselves of this freedom, but had ordered the appointment of a non-competitor;—that it was the present Government who, by consenting to a committee of inquiry had revived the honours of the competition;—that the committee had pronounced the two styles to be equal as to all practical advantages;—and, finally, that the report of the committee had placed the three first premiated designs before him on terms of perfect equality, simply recommending that he should make his choice *from among them*. He closed by quoting an opinion expressed some time back by Mr. Tite himself, that no man of taste would wish to see buildings erected on that site in the style of those which had received the first premiums for the Foreign and War offices.

Lord Palmerston and Mr. Coningham soon repeated their outbursts against Gothic architecture, as boldly as if their old statements had never been answered. The House, however, by this time discovered that party-feeling had much to do with this line of conduct, and, having ascertained from Mr. Scott's letter the fallacy of many of the allegations, they listened with evident impatience.

Now we have no wish to become the partizans of either school of architecture, nor to assume to ourselves duties rightly belonging to the Judges, the Committee, and the First Commissioner, but we decidedly object to the discussion of such difficult questions as that now under consideration by persons unacquainted with them, and still more strongly deprecate the use of oft-refuted statements as the principal weapons in a controversy. Can the member for Bath so soon have forgotten that the windows of the Gothic design in question were considerably larger than is usually found in public buildings in the Classic style;—that they opened as ordinary sashes;—that their several lights were of great width;—that they were proposed to be glazed with large sheets of plate glass? He certainly had once been aware of this, inasmuch as he sat as one of the members of the committee before whom it was given in evidence, and was himself an active man in making the inquiries which elicited the information. How then comes it that from his observations in the House the contrary of all this might be inferred? Mr. Tite had heard, too, from the evidence of at least unbiassed individuals, that neither in convenience nor in economy of cost could one style claim any preference over the other. Why then should he, in his place in parliament, state the reverse of this? Mr. Scott had expressly said that he should make no attempt to "Gothicise" the surrounding buildings, and the honorable gentleman must have been aware that all the competitors (whatsoever their style) had supposed that the State Paper Office was to be removed: why then should he allow Lord Palmerston to state the contrary on the former point, and to attribute the latter to Mr. Scott alone, making it appear, too, that it was proposed on the score of *style*?

As to the question of the fairness of the decision come to by Lord John Manners, so much confusion seems to exist, that it may be worth while to attempt to clear the matter of some of its perplexity, by recapitulating a brief outline of the circumstances.

1. At a meeting of architects convened by Sir Benjamin Hall previously to the competition, he assured them that it should be open to all styles;—that the premiums would be awarded not by himself, but by judges to be nominated for the purpose; but that he did not hold himself pledged to appoint the architect who should be selected to receive the first prize, but (to use his own words) "left it open to himself to determine, if he should think proper, upon recommending to the Government *any* of the designs which might be premiated by the judges."—(See evidence, question 1148).

2. It was found by the committee that Mr. Burn and the professional assessors had, in the lists made without any communication one with another, agreed in placing Messrs. Coe and Hofland, to whom was allotted the first premium, only *sixth;* and that while they placed Messrs. Banks and Barry first for the one building, and Mr. Garling first for the other, they had placed Mr. Scott second for *both*,—a position which Mr. Burn (in answer to question 1189) gave it as his opinion was "the most distinguished of any."

3. Among the seven premiums awarded for the Foreign Office, *three* were bestowed upon Classic, and *four* upon Gothic designs. Among the former, according to the judges, Messrs. Coe and Hofland stood first, and, among the latter, Mr. Scott. If, however, the opinions of the professional judge and of the assessors be preferred, Messrs. Banks and Barry stood first in Classic, and Mr. Scott double-first in Gothic; for in their opinion he was first in his style for both buildings.

4. The committee, in their report (paragraph 10) pronounced the two styles to be perfectly equal in the advantages they offer, and, by calling special attention to the difference between the award of the judges, and the private lists of Mr. Burn and the assessors, they virtually pronounced the designs to be—to say the least—equal the one to the other.

5. Between, then, these equal styles and equal designs, why, we would inquire, should Sir Benjamin Hall attempt to deny to his successor the same freedom of choice which he had taken so much care in reserving to himself? On what grounds does Mr. Tite admit the evidence of Mr. Burn and the assessors to the extent of displacing Messrs. Coe and Hofland, and reject it as establishing an equality between Messrs. Banks and Barry and Mr. Scott?

Digitized by Google

And, finally, on what conceivable plea does the ex-premier attempt to argue that *he* was doing right in rejecting all the competitors, and Lord John Manners wrong in exercising the power reserved by his predecessors in choosing between the three first prizemen, whose styles and designs the committee had in effect declared to be on an equality, and between whom they had expressly recommended him to make his choice?

We will only add, without expressing any opinion here as to the relative merits of the designs, that the selection having been made by the responsible minister, and having been followed up by the appointment of the same architect to the New India Office (in conjunction with the official architect to that board) it would be a really dangerous precedent were these appointments now reversed: and, further, that Mr. Scott's position in his profession,—as proved by his numerous works, by his being elected a member of the Royal Academy, and by his having received, within the last few days, the award of the Victoria gold medal from his brother-architects of the Institute,—furnishes a practical guarantee as to the propriety of the choice arrived at.

ON TIMBER FRAMING.*

By S. C. Capes.

(*With an Engraving.*)

The chief practical object in framing timbers is to arrange them in the best position to withstand, with the greatest economy of material, the various forces which are likely to be brought to bear upon them, and this desirable result is only to be obtained by judicious combinations of the materials to be used; but unless the effect of pressure and the resisting powers of the different materials be understood, how are such combinations to be designed?

It is wholly unnecessary to advance reasons for adopting correct principles in preference to being guided by opinions, as opinions are often hastily formed upon confined and imperfect views of the real nature of the subject, and we can seldom if ever refer with any degree of certainty to the grounds on which they are founded; but a maxim drawn from science can always be examined and traced to its origin.

It is therefore only through a knowledge of the rules for ascertaining the respective strength of timbers in proportion to their scantlings and positions, together with the composition and resolution of forces, that any one can expect to arrive at excellence in the art of designing frames of timber; as without this knowledge it would be impossible for him to understand clearly what is to be aimed at in such designs, or even know whether any design of his own would answer its intended purpose or not. I will therefore now as briefly as possible give you a few of the leading rules, together with some practical remarks upon construction, as we may have occasion to refer to them hereafter in the comparison of the several examples of construction which I have brought before you.

Timber is exposed to three principal actions:—1. Cross strain. 2. Tension. 3. Compression. Cross or transverse strain is the amount of weight applied to the sides of a piece of timber tending to produce fracture in its cross-section. The strength of timber to resist fracture in this direction is as the breadth and square of the depth directly and inversely as the length. The general formula being

$$\frac{Cad^2}{l} = W.$$

That is, if you want to find the weight that will break a beam of wood supported at each end and loaded in the centre, you must multiply the breadth of the beam in inches by the square of the depth, also in inches, and by the constant or tabular number for the material used—which for the best Baltic timber we may take as 400—and divide by the length in feet;—the product will be the breaking weight in pounds. When the weight is distributed over the whole length of the beam it will require double this weight to break it. When the beam is fixed at one end only, and loaded at the other, it will only require one fourth of the result to break it. When the weight is equally distributed on a beam fixed at one end only, one half of the result will break it. The permanent load should never exceed one third of the breaking weight.

* Paper read before the Architectural Association.

2. Tension is the amount of force or weight applied to the ends of a piece of timber, tending to tear asunder in direction of their length the fibres or particles of which it is composed. The strength to resist the force or weight that produces fracture is as the area of the cross-section acted upon. Hence multiply the area of the cross-section in inches by the constant representing the power in pounds, and the product will be equal to the weight in pounds the rod or piece will just support; the constant for fir timber being 11,000 lb., but the greatest constant load should never exceed one fourth.

3. Compression is the amount of weight having a tendency to crush the material. The rules for determining the dimensions of a piece of timber to support a given weight without sensible flexure, are very complicated; but this may be taken as a guiding principle, that if the height of a column or post exceeds a certain multiple of its least sectional dimension, it will give way, not by crushing, but by bending, and will ultimately be destroyed by the cross strain. This flexure occurs in oak or fir timber when the height exceeds ten times the least dimension, the resistance decreasing very rapidly in proportion to the increase of the number of times the least dimension is contained in the height. A post in height 100 times its diameter is incapable of maintaining an upright position.

If a piece of timber AB (fig. 1) be inclined on its base, its strength to support a vertical effort diminishes in proportion to its inclination; so that if from its upper extremity a vertical, D*f*, be lowered, and from the points of the base B, a horizontal line BC be drawn, the strength of the piece will be less in proportion as B*f* is larger; whence it results that the strength of a strut AB is to that of an inclined piece of the same scantling as the length AB is to D*f*, or as the radius to the sine of the inclination of the timber.

Before setting to work to design any system of framing, the following important proposition in mechanics, which shows the composition and resolution of forces at a point, should be thoroughly understood:

Proposition.—If the adjacent sides of a parallelogram represent the component forces in direction and magnitude, the diagonal will represent the resultant force in that direction.

Let A*f*, A*g* (fig. 2) represent in magnitude and duration the forces FG acting at A; complete the parallelogram A*f*, E*g*, and draw AE.

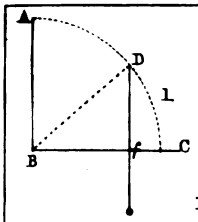
Suppose, for instance, an upright piece of timber pushed in direction of its length by a load at B (fig. 3), and abutting on the ends of two beams AC, AD, which are firmly supported at CD; and as they cannot move, the pressure they sustain from the post BA is in the direction AC, AD. To ascertain what each of these timbers sustain, we must produce BA to E, taking AE from a scale of equal parts to represent the number of tons or pounds by which BA is pressed; drawing EF and EG parallel to AC and AD: then AF measured on the same scale as AE will give the number of pounds by which AC is strained, and AG the strain AD.

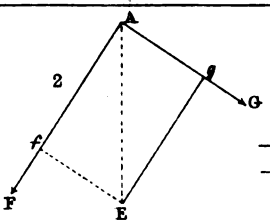
To properly brace a piece of carpentry so as to resist any force that may be applied to it, and to give the necessary stability, requires careful arrangement and considerable knowledge in the art. In framing one timber into another it must be remembered that all timber is liable to shrink when dry, and when wet to expand. On this account all joints should be made with reference to their contraction and expansion, which sometimes tends to split off portions of their framing; and as all framing will settle more or less, the carpenter will see how important it is to make the joints of struts, &c. (fig. 4) when first fitted, bear on the opposite edge to what they will have to do when finally settled. To remedy this course Tredgold proposed to make the joint in the form of an arc (fig. 5), in order that the pressure on every part might be equal. Great care is also required when the framing has to bear considerable weight, to prevent the ends of the timbers eating into the sides or bearings of those against which they abut; for this purpose sheets of lead or iron plates and shoes are now often used.

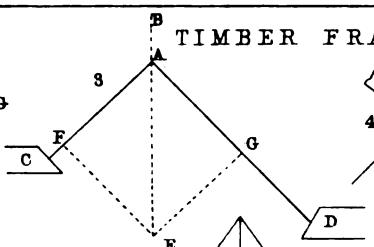
One great consideration in designing timber framing is so to arrange that it can be constructed of such scantlings as are easily obtainable in the district where it is intended to be used. Great ingenuity is frequently shown in joining comparatively short pieces of timber together, where great length is required for ties, beams, &c., by a system called scarfing (fig. 6); but it is perfectly clear that the joint cannot have half the strength of an entire piece.

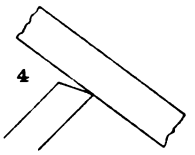
Digitized by Google

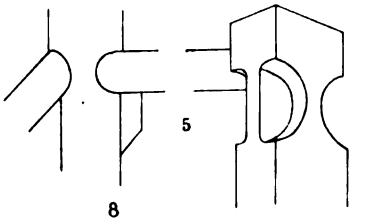
TIMBER FRAMING.

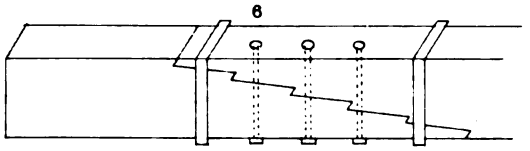


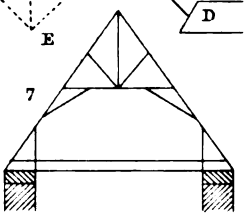


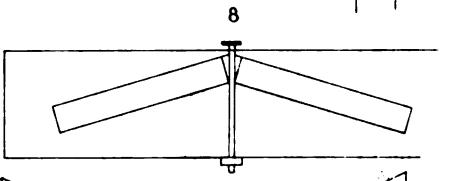


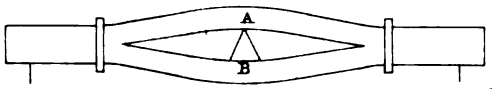


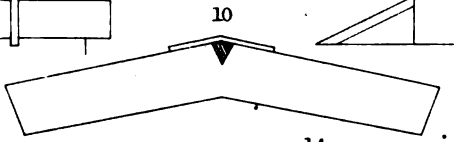


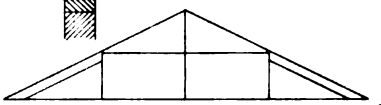


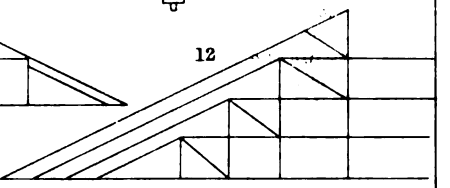


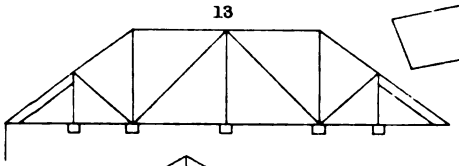


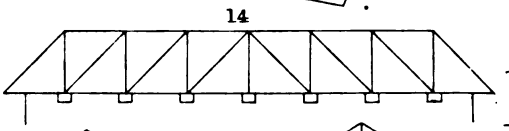


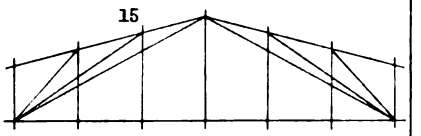


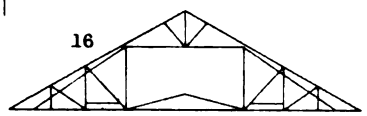


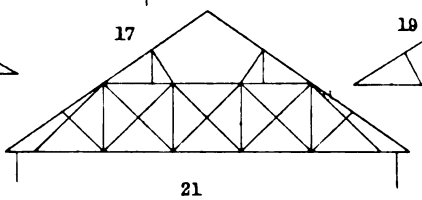


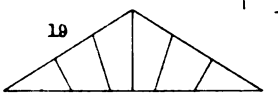


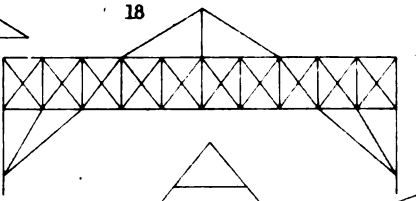


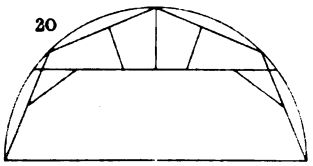


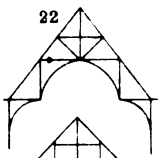


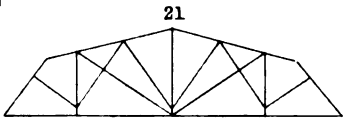


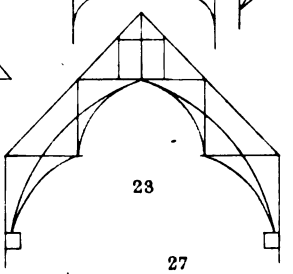


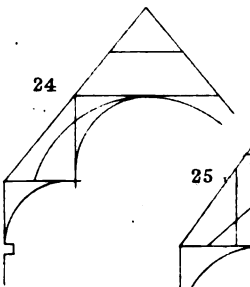


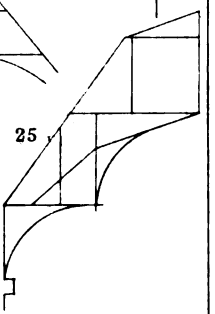


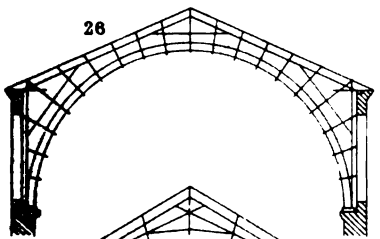


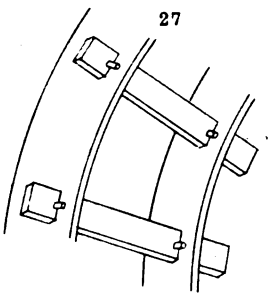


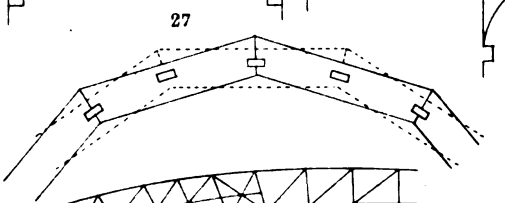


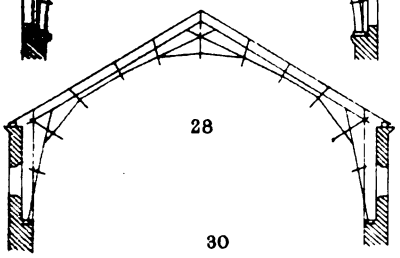


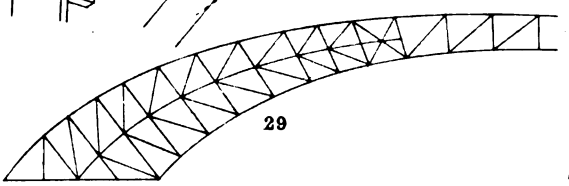


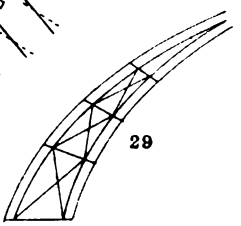


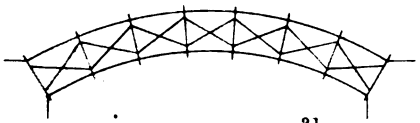


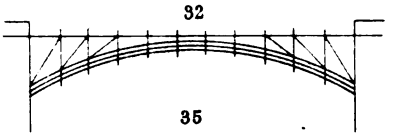


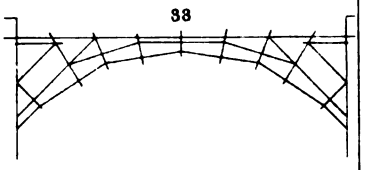


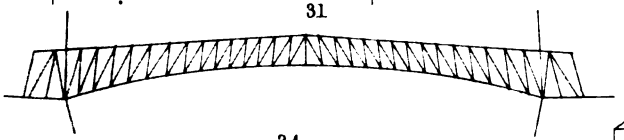


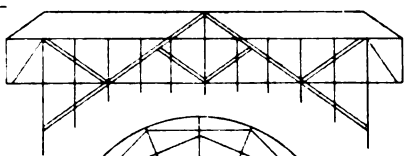


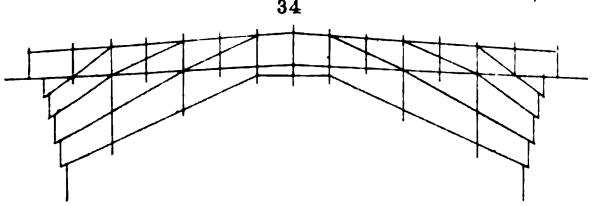


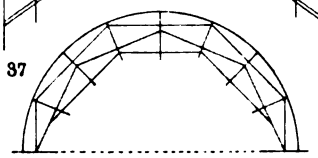


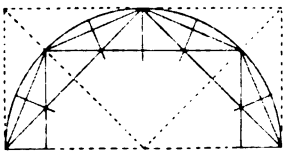












Digitized by Google

Digitized by Google

The necessity for timber framing arises most frequently in girders, partitions, roofs, bridges, centres, and scaffolding. Nearly all descriptions of framing may be divided into two classes, viz., girders and arches; the former exerting only vertical pressure upon the points of its support, and the latter horizontal or angular pressure, in accordance with its form.

The earliest use of timber was doubtless in the construction of rude huts, which we may suppose to be formed by trunks of trees, or posts, with one end fixed into the ground, and inclined or pitched one against another in a triangular form, serving for rafters, which would support such materials as might be placed upon them for the purpose of keeping out the wet, heat, or cold. An improvement upon this method would soon follow with the desire of raising the roof upon rough walls or embankments, so as to enable the inhabitants to walk erect beneath it; in which case it would soon be found necessary to provide some means for preventing the ends of rafters from forcing out the walls, which would either be done by tieing each pair together with a horizontal beam secured to the rafter feet, or by strengthening the walls with an increase in the width of their base;—the one afterwards developing itself into the so-called tie-framing, exerting only a vertical pressure on its supports,—and the other into thrust-framing, supported by solid abutments.

We may naturally suppose that in the earlier times, before the science of construction was understood, and the nature and properties of timber to withstand the various strains were discovered, that a great excess of material was often employed; and where timber was plentiful its economic use was not considered. In examining the oldest examples that have been described or escaped destruction, we see that the use of suspending pieces, such as so-called king, queen, and other posts, was either unknown or ignored; and, although posts were used in similar positions, they were employed more in the character of struts, and were not supposed to assist in hanging up the horizontal tie-beam, which was usually of great strength, sufficient to carry any weight likely to be brought to bear upon it. As construction became more developed the scantlings of the timbers were decreased, and each piece became more proportioned to the office it had to perform. Advantage was taken of the enormous power necessary to crush and tear asunder timber in direction to its length, as well as the unchanging principle of the triangle, to construct framing in accordance with its form; and by firmly securing the principal inclined timbers to the ends of the horizontal pieces, to make use of the power thereby obtained at the apex of the triangle to suspend therefrom vertical timbers, hanging up thereto the tie-pieces, and forming abutments for smaller inclined timbers, obtaining thereby an increase of strength with a decrease of material.

The introduction of iron for straps and bolts offers us many advantages in the construction of framing which the carpenters of the middle ages do not seem to have been acquainted with, as they generally formed all their joints in such a manner as to answer as far as possible the same purpose, the shoulders of all timbers being accurately cut and framed, and secured by oak pins. Oak was also extensively used by them as a material for framing, which would consequently cause the joints to have much greater strength than could be obtained in fir timber. The early Gothic roofs were very simple in construction, consisting often of rafters and collars, with tie-beams independent of the other timbers, and merely connecting the wall-plates. In some of the high-pitched roofs of our parish churches we find, at about half their height, the principals connected by a collar, upon which stands a tree-post (fig. 7), strutting up the principals. Beneath the collar are usually thrown in two braces, which are framed into it and the rafters. Such a roof, with a tie-beam to hold in the plates, will endure for ages. The tie-beams were usually in depth equal to $\frac{1}{18}$ of their length between the walls, and all the rest of their timbers in proportion.

Before entering upon any remarks on the thrust and hammer-beam roofs of the middle ages, I will finish my explanation of the several examples of tie-framing or trussed girders.

Trussed girders where depth is limited are usually formed of two pieces of timber bolted vertically together, with a core of oak or other hard material let into inclined grooves, and well secured at the ends and middle, and having a king-bolt at apex (fig. 8). A piece of iron or lead should be introduced at the abutting ends of truss, and sufficient play left in the grooves for the flitches to camber when the king-bolt is tightened.

One of the most simple methods of trussing is by cutting the girder horizontally for a considerable distance in direction of its length, and wedging between the upper and lower portions,—the ends of the cutting being prevented from splitting further by means of bolts or straps. Mr. J. Laves, of Hanover, brought this system extensively into use in that kingdom. He gives a little more depth to the upper portion A, than to the lower portion B (fig. 9).

Some have taken advantage of the difficulty of crushing timber in the direction of its length, and have applied it ingeniously for obtaining strength in girders. A saw-cut is made across the middle of the girder to a depth of one-third of its vertical thickness; it is then bent upwards (fig. 10), and when the cut has opened sufficiently a wedge is introduced into it, thus making it camber, and consequently stiffer. It has been proved that beams so cut and prepared are one-sixth stronger than those of the same scantling unsawn.

The most simple and economical truss to openings up to 30 feet span, and one most usually adopted, is the ordinary king-post. Above 30 feet span the introduction of two or more suspending pieces becomes necessary. We find this principle adopted very early in Italy, and particularly in the roofs to the Basilicæ at Rome. In the church at Rome of St. Paul's, without the walls, erected about 400 years ago, where the span is nearly 79 feet, was a finely constructed roof: it consisted of pairs of trusses placed 15 inches apart, each pair resting on the walls with a distance of 10 ft. 6 in. between them. The manner in which the trusses were framed together was very simple, and formed a remarkably strong roof. A king-post received the upper ends of the principal rafters, which were about 22 inches by 15 inches; a collar or straining piece abutting against the heads of two queen-posts, the position of which was retained by additional timbers placed under the principals, and forming a double thickness where the greatest strength was required (fig. 11). The tie-beams, 28 inches by 15 inches, were formed by scarfing two lengths of timber together, and securely strapping them with three stout irons. The collar was placed at two-thirds the height of the king-post, and by the introduction of the pair of queens the tie-beam was hung up in three places to prevent its sagging. Such a suspension of the tie-beam by the middle, and again at 14 feet on each side of it, exhibits a thorough knowledge of the true rules which should direct the carpenters. No tie-beam should exceed the length of 15 feet without some precaution similar to these being adopted to prevent it drawing in the wall-plates and crippling the truss. In this example we have an early instance of suspending the tie by means of the heads of the king and pair of queen posts, and which system is now universally adopted. For roofs of considerable span an arrangement of horizontal and vertical ties has been successfully employed, each horizontal timber becoming both a strut and a tie.

The roof of the Riding School at Moscow, as it at present exists, is framed somewhat on this principle (fig. 12). A series of ties and struts in succession are united into one simple and complete truss. These are placed 13 feet apart; the tie-beams formed of two thicknesses of timber scarfed together, each 12 inches square, forming a depth of 24 inches. At every 3 feet of its length were introduced iron bolts 1 inch in diameter. Double keys of oak driven into notches formed at equal distances between the two beams, assisted in resisting the horizontal drawing of the extremities. The middle of the tie-beam was drawn up 13 inches by the middle or centre post, which is 32 feet in length, or one-fifth of the total span. Above the chief tie-beam are three others, placed horizontally at equal distance, which are tied together in a similar manner. The rafters, formed of several stout timbers, are capable of supporting considerable weight when held firmly at their abutments; and the tie-beams, strongly bound together to prevent any drawing out, may be suspended to the principals. A series of iron straps or bands passed round the feet of the principal rafters, and secured to the tie-beams, effectually prevent any rising or spreading of the main timbers.

Palladio's bridge, near Bassano (fig. 13), is an amplification of the queen-post and strut principle. The following is a description of it: five transverse beams, 12 inches square, are disposed at equal distances in a span of about 108 feet, making them 18 feet apart. These bearers carrying the roadway are bolted to the tie-beam and five suspending pieces, the heads of the latter forming abutments for the principals and struts, all the timbers of truss being 12 by 9 inches. Considerable increase in strength is obtained by cambering the tie-beam. These trusses form the parapets, and are secured by iron straps and bolts at the extre-

Digitized by Google

mities. They are capable of supporting considerable weight without any sensible deflection; their height is about 16 feet, or nearly one-seventh of the span; and the introduction of the series of triangles—a form least liable to any change—gives great strength to this bridge.

I here call attention to another of Palladio's designs for bridges (fig. 14), supported like the last by a truss on each side, its length being divided into eight bays by transverse girders suspended by stirrup irons and bolts from the post, framed into head and cill of truss; these posts are braced strongly. But the strength of this truss is not equal to the other design, the centre bays being liable to drop, as the bearing is too great for the depth of girder. In this construction the first bays forming the abutment should have four depths of cill; the second three; and the third two; thus the ends of the bridge would appear to rest on corbels gathered over from the abutments. The height of the truss is about one-tenth of the span.

The principle adopted in the celebrated bridges at Schaffhausen Zurich, Landsberg, Wittengen, &c. (fig. 15), is to throw the weight directly to the ends of the tie-beams, and not, as in the preceding designs, distribute it over the whole length, the braces acting in the same manner as the extra depth of cill there proposed.

The former roof over Exeter Hall, with a span of 76 feet, is of a very strong form, having its tie-beam, 14½ by 7½ inches trussed in the centre, so as to obtain a considerable extra amount of compressive strength. Principal rafters and collar 14 by 7½ inches, with queen-post 8½ by 7½ inches in smallest section. Over the collar is a king-truss, with the principal rafters, 8½ by 7½ inches, running from king-head, and tenoned into the tie-beam of queen-truss, giving considerable extra depth to the queen principals. The space between the queens and the abutments of rafters is divided into three bays by pairs of suspending pieces, 12 by 4½ inches, clipping both tie-beams and principals, and bolted thereto with stirrup-irons; struts and straining pieces being introduced to take advantage of the incompressible power of timber in direction of its length.

The roof over Drury-lane Theatre (fig. 16), as designed by B. Wyatt, is of 80 feet span, and of very similar construction, the timbers being generally of greater thickness in proportion to their depth than the former, so as to obtain more lateral stiffness, which is further increased by the additional purlins placed between the two principal rafters. The suspending posts and straining pieces are of oak.

In the roof over the Boston Depôt of the Boston and Albany Railway (fig. 17), is a very fair specimen of the diagonal bracing, which is applied very successfully in America. The trusses, 94 feet span and 16 feet apart, being each formed of a tie-beam 9 by 12 inches, the principals, 8 by 12 inches, laid flatways, and rising 31 ft. 4 in. At half the height of the triangle so formed is a collar 7 by 12 inches, which is divided into three equal parts; from each division is dropped a 1½-inch iron rod, suspending the tie-beam, and each bay filled in with diagonal bracing 5 by 5 inches, bolted together at the intersections, the suspending rods also passing through and screwed up to the underside of longitudinal timbers, 6 by 8 inches, to stiffen the roof; similar bearers are secured at the top of the collar to the two centre rods, against which abut struts to the principals, and at the junction of struts and principals similar rods and bearers are introduced. Purlins, 6 by 8 inches, are placed every 10 feet apart, which carry the rafters, 4½ by 3½ inches, 2 feet apart, and covered with inch-boarding. Strengthening corbels are introduced to the ends of e-beams.

Somewhat similar framing is used in Long's American bridges (fig. 18). Deep outside girders are formed by a series of diagonal bracing, with upright posts framed between string-pieces, and connected with each other in a similar manner at top and bottom, forming a kind of tubular girder, the centre posts being carried up above the level of girders to receive two inclined timbers forming a king-truss above the girder so as to stiffen the centre and to throw the weight more directly upon the abutments, which in large spans are also strutted to give additional strength.

The bridge at Chambley, near Montreal, is of somewhat similar construction, iron ties having been introduced for the timber posts, and the king-truss omitted on the upper portion of girder.

Following out this principle, I now call your attention to the lattice-girder bridges, of which a good example is at Richmond in America, for a span of 150 feet. The lattice framing is composed of fir planks 12 by 3 inches, arranged so as to lie across each other at right angles; at the points of intersection they are united by oak trenails 1½ inches diameter, which pass entirely through them. The outside girders are connected together at every 12 feet by cross timbers diagonally braced, the upper cross timbers forming carriages for the road-bearers, which are placed longitudinally.

Pfeiffer executed several trusses in Germany which derive considerable strength from the introduction of inclined timbers serving the double purpose of holding up the tie-beam to the principal rafters and strutting up the latter (fig. 19). Where timber acts as struts and ties an iron bolt is almost indispensable to secure the joint. These inclined timbers were placed in pairs and halved to the ties and principals. This system answers very well for moderate spans, but I should not recommend its use where any great distance exists between the points of support.

Another system of roofing was carried out to a great extent by Mansard, by whose name it is usually called, the object being to keep down the height of the walls, and getting a more capacious apartment within the roof; the whole is usually arranged within a semicircle (fig. 20), but its system may be said to consist of four pieces, or rafters, hung together in such a manner that if inverted they would naturally assume the form given to them. The tie-beam in this instance is usually one of the common joists of the floor. Sometimes the ties are omitted, in which case a considerable lateral pressure is exerted on the walls, having a tendency to push them out of the perpendicular.

Polygonal tie-trusses are often introduced into roofs and bridges where the height of framing is required to be kept down, the principals abutting against straining-pieces inclined but little from the horizontal line, as in the drawing I have brought before you (fig. 21), which is very similar to the framing designed by Sir C. Wren for the roof-trusses of the Sheldonian Theatre, and of the same span, viz., 80 feet, each being divided into four bays with king and queen posts, and struts running in like directions; the tie-beam of the larger drawing, being only 9 by 4½ inches, has two iron suspension rods in addition to the post.

There are several roofs of theatres which exhibit many ingenious modes of construction, involving the combination of several systems before and to be hereafter described; but it would occupy too much of our time to enter into lengthened descriptions of them. The great object generally to be obtained is to get as much clear space and available height in the roof for scene painting and other purposes; the purlins being oftentimes trussed, as in the example of the Napoleon Circus, and the floor which forms the tie suspended therefrom.

In the middle ages all judicious timber roofings ceased in buildings of pretensions about A.D. 1400, and gave place to roofs without ties,—a principle of construction which bears a nearer analogy to masonry than to carpentry. The timber roofs of the Gothic architects were generally executed in oak, and richly moulded. In our churches we find them formed of pairs of rafters, the feet of which, where tie-beams are omitted, are framed into a piece of timber laid across the thickness of the wall, into which, flush with the inner face of the wall, is framed an upright strut. Collars are introduced at about two-thirds the height of the roof, and braces similar to those described for tie-roofs (see fig. 7); or, as in many instances, extra strength was given to the trusses by inserting a framed timber pointed arch in lieu of braces. These were carried down some distance below the wall-plate, so as to throw some portion of the weight of roof upon the corbels built into the wall, and upon which the arch braces rest.

By lengthening the foot-piece in the foregoing examples, so as to project beyond the inside face of the walls, we obtain the hammer-beam, from the end of which an upright strut was carried to the underside of principal rafter, and curved braces introduced both to support collar and hammer-beams (fig. 22). In some instances two ranges of hammer-beams are introduced, the collar being placed very high up in the roof, thereby increasing considerably the liability to spread and exert great thrust against the walls.

Many of the roofs constructed in the fourteenth, fifteenth, and sixteenth centuries are of surprising beauty both in form and workmanship. That over Westminster Hall was finished about 1399, in the reign of Richard II., the principals being 68 feet in span and about 18 feet apart, each formed of a pointed arched rib in its section upwards of 2 feet each way, spanning the width of hall, intersecting at about half its height with a massive hammer beam of similar scantling, and extending on one side to the feet

Digitized by Google

of principal rafters, and on the other to a similar extent; so that, if secured on a central pivot, this timber might be acted upon as a scale beam or lever of the first order, and if loaded equally at both ends would remain in its horizontal position, while the entire weight would be concentrated on the pivot and thrown on the supporting arch (fig. 23). Mr. Thomas Morris, in an essay on Westminster Hall,* read before the Institute of Architects, 24th June, 1850, goes on to say that,—"If, taking the hammer-beam as a base, we draw a perpendicular line from the inner extremity it will be found to cut the surface of the roof just midway between the roof and the ridge, and taking this surface line as the hypothenuse, a triangle will be completed. This triangle will be found to have an exact counterpart in the upper half of the roof; but as the weight is proportionate to the superficial area, it is only necessary to explain that this area is divided longitudinally into two equal parts; that under this divisional line a purlin exists upon which is collected the weight of the upper half of the roof, and this weight is transmitted by a vertical post to the inner end of the hammer-beam. The lower half of the roof discharges in like manner its weight on the outer end of the same timber, and the equipoise is thus rendered perfect."

Although I do not quite agree with the opinion that this equipoise is perfect, yet, as the earliest known example of importance of the hammer-beam roof, I must allow that its design evinces a masterly knowledge of the principles of construction, and which was never surpassed in any subsequent example.

Eltham Hall, 36 feet in width, is spanned by trusses 17 feet apart (fig. 24), the length of the rafters about four-fifths of the width; so that it has not so great a pitch as Westminster Hall. In this example the arches and struts are obtusely pointed and struck from four centres; the whole weight is thrown on the top of the walls, the bottom struts being scarcely of any use in distributing the weight downwards. These trusses have a much greater proportion of timber to that of Westminster.

Hampton Court Hall, completed about 1537, is 40 feet wide, and its roof is of very superior construction to that of Eltham,—the hammer-beam projecting full one-quarter of the span, while that at Eltham only one-fifth; and the weight of the roof is carried down a considerable distance below the hammer-beams by the wall-posts and struts (fig. 25).

In examining the principles of these beautiful roofs, of which we have so many remaining in England, we find that the pressure against the walls is sometimes too oblique; and the buttresses have yielded after the strong plates laid upon the walls had given way, as in the case of Eltham; and in many cases little or no provision was made for properly trussing the principals, which are often found crippled with the weight they had to carry.

In more modern times a system of framing assimilating to the semi-arch is generally employed where ties are omitted, and has all the properties of arch construction.

In 1561 Philip de Lorme published a method of constructing roofs and domes with timbers, or rather short planks. One of these roofs covered the stables of the Tuilleries at Paris, and after remaining sound and secure for 234 years was demolished to make way for some improvements in the palace. The arches were formed of two planks, 9 inches in width, cut into convenient lengths for the required form; this seldom exceeded 4 feet, and were applied to each other in thicknesses to form the rib, and so laid that the ends of one set came in the middle of the others. Mortices were then made in them, through which were longitudinal ties, and these had a small wooden pin passed through them on each side of the circular ribs to keep them in their upright position and to prevent them twisting (fig. 27).

In some of the buildings executed by this architect, when the span of the roof exceeded 60 or 70 feet two ribs were used, so put together that they partook of the character of hollow voussoirs and were very strong.

Another instance of the success of De Lorme's construction was the original dome of the Hall au Blé at Paris, 120 feet diameter, built by Legrand and Molino. This roof was destroyed by fire, and is now replaced by an iron one.

In London we have an example of this system of roof over the central compartment of the Pantheon, Oxford-street, 38 feet span, designed by Sidney Smirke.

Some objection has been made to this mode of construction on account of the labour required in cutting the number of mortices, making the longitudinal ties and introducing the pins; therefore in some instances the mortices have been omitted, the planks bolted and spiked together, and the ties nailed to the upper and lower edges, the latter as ceiling joists or boarding. Nevertheless there exists in these roofs considerable waste of material and great labour as compared with some other roofs of similar spans.

Colonel Emy, a French engineer, proposed in 1817 an improvement on De Lorme's system, by using the planks in the reverse position; in fact being precisely the laminated arch of the present day. On first sight it may appear that De Lorme's plan is the strongest, as the depth of the planks is greater than their width, from their being placed edgeways: in the other system thin boards are bent upon templets to the proper curve, and kept from separating by iron straps and bolts, as also by radiating struts, which are in pairs, notched out so as to clip the rib between them; the joints are much fewer, and the fibre of the wood coinciding with the curvature of the rib gives it considerable elasticity, so as to slightly yield rather than break under any violent strain. I bring before you two examples,—one, a segment rib of 64 feet span, springing from a plate on the floor of a store-room, which floor forms a tie; the other a semicircular rib over a riding school at Libourne, of 68 feet span, erected in 1826 (fig. 26).

The principle of this roof is good. The principals, wall-posts and arched rib form two triangles, firmly braced together, and exert very little thrust on the walls, most of the weight being thrown vertically on the wall at foot of ribs. The walls, though of considerable thickness, are further strengthened by buttresses. I may here mention that the roof of King's-cross Station is constructed of laminated ribs, but maintained to their semicircular shape by being fixed to iron stanchions, built into the wall and weighted therewith.

Colonel Ardent, who found some difficulty in obtaining in many parts of France fir planking at reasonable prices, and where squared oak timber was in abundance, designed some roofs for riding schools according to the accompanying sketch (fig. 28), which as you will observe, follows very closely upon Colonel Emy's principle. Considerable lateral stiffness is obtained by a deep cross strutted ridge, while in Colonel Emy's roofs a series of longitudinal timbers at back of arch are inserted for the same purpose. Other roofs of far greater span have been constructed by the same engineer (Colonel Emy), who after many experiments suggested the employment of a double curved rib, having different radii; these held in at the springing were in the spandrel braced by timbers ranged like St. Andrew's crosses; iron bolts or timber binding-pieces, pinned at the sides, hold the masses together.

In circular buildings, domes and roofs may be constructed by omitting the usual ties, and introducing continuous or annular binding pieces at the springing of the roof, of sufficient strength to prevent its spreading unequally; each portion of the roof counteracting any effort on the part opposite to it. In this case the total dependence is upon the strength of the binding-pieces, rings or plates being such as are able to perform their duty without fatigue. I give the Napoleon Circus at Paris, designed by M. Hittorff, as an example. The plan of the building is a polygon of 20 sides, and upwards of 130 feet internal diameter; the external walls are comparatively slight, and the roof, without any intermediate support, is formed by trussed principals, abutting and pitching against strong framed oak rings. At each angle of the building are three-quarter Corinthian columns, upon which a considerable portion of the weight is thrown.

In these, and in all other descriptions of framing which are not designed upon the girder principle, the slightest alteration in the abutments will destroy the entire system, which is entirely dependent upon the immovability of its points of thrust for the continuance of its shape, use, and existence; therefore this thrust principle must be always inferior in point of construction to those I have previously described as girders.

One of the four designs left us by Palladio consists of a timber arch formed by radiating binding pieces connecting top and bottom rib, and strengthened by diagonal framing (fig. 30). This principle has been much employed in roofs and bridges. Dublin Exhibition roof, of 100 feet span, was upon this system. The upper and lower ribs were composed of thicknesses of planks laid vertically. The other design of Palladio's, with which I found fault for being weak as a girder, has been very successfully adopted as an arch of 340 feet span over the Schuylkill, at Fairmont, near Philadelphia. It had no other support but that of the two abutments: the versed sine was 38 feet, and width of carriage-way 30 feet; all the posts, which were of large dimensions, radiated to the centre, and the abutments were formed of

* See *C. E. & A. Journal*, vol. xiii. p. 249.

Digitized by Google

solid masonry, carried up to a considerable height above the bridge (fig. 31).

The laminated arch now finds most favour when arches of large span are required for viaducts or railways; and, where sufficient caution has been taken to prevent too much motion from their elasticity, have been found to answer very well.

Cressy, in his Encyclopædia, remarks that when the opening of the arch is considerable, the movement of carriages and sometimes the action of the wind alone occasions oscillations in the horizontal direction, which injure the carpentry, and become very dangerous. The greatest care should be taken to prevent this. In the oscillation of an arch the entire system of its carpentry may participate in its movement, or it may be only partial,—for example, the floor may to a certain extent move independently of the arch: still it is very important to oppose these effects. There are therefore, placed between the first course of pendant binding pieces near the springing, inclined struts, which secure the union of the floor and the arch; and it appears that this disposition gives to the arch all the solidity and stability which could be desired. It is scarcely necessary to observe that the framing of all these pieces should be secured by bolts, without which the union could not be obtained (fig. 32).

Many thrust-bridges are constructed of timbers forming polygonal arches, similar in character to the roof of Colonel Armand, but, being composed of too many pieces, are often defective (fig. 33).

Whatever may be the combinations in constructions of carpentry, the object should always be the transmitting of certain efforts to points of support by means of a system of levers subjected one to the other. Now we can distinguish in such a system two different equilibriums, which we may designate, equilibrium of position, and equilibrium of resistance. The first takes place when the efforts exercised on each lever are so combined with their respective situations that the system does not tend to produce any movement. The other consists in making each lever have the necessary force for the resistance of the pressure exercised on it.

A system of levers may be maintained in repose by two different means: first, it may be disposed in such manner that the conditions of the equilibrium of position should be exactly satisfied; secondly, the levers should be so subjected to each other by framing or auxiliary pieces, as binding pieces or braces, that it should be impossible for them to change situations with regard to each other, so long as the resistance of this framework is superior to the efforts which tend to make the form of system vary. In this latter case we are not required to satisfy the conditions of the equilibrium of position.

In the case of bridges, where the weight they have to carry is a constant moving weight, the levers should be placed so that they do not tend to any change of form under the load. It is consequently evident how disadvantageous it is that the two halves of a principal should be divided into a great number of articulations, forming so many points of rupture, leaving them no resistance but that which arises from the strength of the framing. It is therefore very difficult, when the number of levers is considerable, to fortify them sufficiently so as to procure for each half of the span a resistance capable of making equilibrium to the pressure which it exercises in the direction of the length. It is for this reason that the bridge at Calais, and many others, are defective, from being composed of too many pieces, which must be subject to considerable shrinking, and thus become shortened: when heavy loads pass over, they have a tendency to open and derange the whole framing.

In the bridge at Berne, over the Kandel, constructed by Ritter in the year 1764, (span 166 feet,) its height above the water has allowed the struts to be placed in a more judicious position, and inclined almost parallel with each other. They are all about 11 inches square, and the longest is about 75 feet (fig. 34).

The bridge over the Soane, at Lyons, designed by M. Gauthey, for an opening of 164 feet, was upon the foregoing principles. It was intended that this bridge should have three sets of longitudinal timbers, one passing through the middle, which would have given two independent thoroughfares (fig. 35). I may here remark that although Soane, Berne, Wittengen, Schaffhausen, Simmut, and a few others were at one time named as works of carpentry not to be surpassed, yet the binding of timber into arched forms has in more modern times been found not only stronger but more economical and durable.

Mention has been made of several of these bridges: I will now add to the list that of Mellingen, 157 feet span, with an arched rib formed of six pieces of fir, each 10 by 10 inches, bolted on each other; and one over the Seine, 104 feet span, with four thicknesses of timber 10 inches square, as above. One at Bamberg, over the Regnitz, in Bavaria, of 206 feet span, with a versed sine of 16 ft. 6 in., of ribs formed of three pieces of timber in the centre, 14 inches square, and five pieces at the ends of similar scantling. Many others by the same engineer, Weibeking, of spans averaging 100 and 200 feet, also exist in Bavaria. M. Weibeking usually gives 25 feet for the ordinary width of his bridges, and the rise in roadway 1 in 24. He found that timber bridges, when constructed on his principle, would settle 1 foot in 72; so that to have a rise of 1 in 24 when finished it must be framed for a rise of 1 in 18, which will be sufficient for moderate spans; but the greater the span, the greater must be the rise.

The subjects of centres and scaffolding deserve some little attention at our hands, being quite as important a branch of study; for upon the proper construction of the centering for arches the stability of the arch depends. In constructing the arches of a bridge of any considerable span, where the form is that of a semicircle or semi-ellipsis, after the voussoirs are laid to a certain height, the timbers of the centre are compressed, occasioning the crown or upper portion to spring, producing a considerable change of form. This inconvenience can be partially obviated by loading the summit as the process of laying the voussoirs advances; but this precaution will not prevent the centre from altering towards the haunches. Whenever a tie-beam is omitted in that part where greatest pressure occurs, compression and change of form are the consequence. Centres with tie-beams are always to be preferred to those formed by parts of polygons inscribed within each other, as when constructed without horizontal timbers in the direction of the greatest compression, they must yield very considerably.

In order to find a combination of pieces of timber which shall resist the effect of the voussoirs, we must first determine the position of the tie-beam. For this purpose, whatever may be the shape of the arch, draw from its springing and crown two tangents meeting at a right angle, through which drop a line perpendicular to the curve, and its intersection with which will determine the position of the tie-beam (fig. 36). Perronet in his system, as published in his work on Bridge-building, has omitted the tie-beam, and the examples given may be regarded as composed of a number of trussed or framed voussoirs (fig. 37), and are subject, as he found, to great disarrangement if not loaded very carefully.

In some instances fixed centres are preferred to the moveable ones before described, in which case the framing is built up from a solid foundation, or several points of support, as in scaffolding; and many ingenious plans have been adopted for easing the framing, to allow the superincumbent weight to find its equilibrium before entirely removing the cradling on which it had been placed.

The usual method in England of erecting scaffolds with round upright poles and horizontal ledgers, with putlocks resting on same and having a bearing on the wall, is familiar to you all, and does not require much knowledge of construction to design for ordinary purposes; but in some cases the architect, where the buildings to be erected are of an unusual description, has to design also the scaffolding requisite for its erection; and in such cases, as greater strength and solidity are required, it is usual to employ squared timber: very great strength, combined with simplicity, is often observed. The scaffolding to Nelson's Column, London, is a good example.* This was designed and executed under the direction of Mr. Allen. The whole was composed of unsawn timber, and the total height was 180 feet. The upright timbers are slightly tenoned into the horizontal, and where the joint was made iron dogs were driven into the timbers in a diagonal direction across the joints; these afterwards were easily withdrawn, and the timber but little injured. The scantling of all the timbers was 14 inches square, the base of the scaffold was about 92 feet square, without measuring in the raking braces. There were in all seven stories, and the whole strengthened by flying wind braces, which were supported by cross transoms, projecting outwards about 6 feet from the perpendicular of the scaffold at each stage. At the summit worked a travelling machine.

* For a description and drawings of this scaffolding, see *C. E. & A. Journal*, vol. vi. p. 409.

Digitized by Google

A MODE OF CONSTRUCTING CANNON, WHEREBY THE STRAIN PRODUCED BY FIRING IS DISTRIBUTED THROUGHOUT THE MASS OF METAL.

By Capt. T. A. Blakely, R.A., M.R.I.A.*

(*Concluded from page 50.*)

Besides the great increase of strength to be obtained by making the exterior portions of a gun do their duty, my mode of construction permits the use of metal in smaller masses; but this advantage and others it shares with many old guns, and with many schemes for making guns. In the Museum of this Institution are several ancient built-up cannon, and the construction of many others in India and elsewhere is well known. The most complete of that kind I ever heard of was one made by Mr. Dundas, of Dundas, of longitudinal staves of wrought-iron, accurately planed and fitted, and held together by cylindrical collars or rings. A 9-pounder made by him, and looking externally exactly like one on my principle, was fired at Shoeburyness at the same time as the other, but burst at the third round with 6 lb. of powder and two shot. This would at first sight lead one to suppose that Mr. Dundas's plan is inferior to casting a gun of iron; such is, however, by no means the case, for I believe Mr. Dundas could make a larger solid-shot gun than can ever be made of cast-iron.

Mr. Joseph Whitworth, of Manchester, made guns consisting of cast-iron cylinders, slit up the whole length, and hooped like the others. His marvellous mechanical genius taught him that the interior would stretch when the exterior was but little strained, and he accordingly made his gun so that the stretching should not injure it. The difference between Mr. Whitworth's plan and mine is, that he prevents the disproportionate stretching of the inside from injuring it; whereas I prevent the disproportionate stretching itself to a great extent, without losing circumferential strength, as he does by slitting the core. I like his plan better than that of Mr. Dundas, because I think cast-iron the most suitable material to put next a shot.

I mention these guns to show you that I am aware that I have been anticipated in all the advantages my mode of construction possesses except one, viz., that I make several different layers of the metal take a full share of the strain, so that thickness gives strength; whereas in all other modes some parts are so nearly useless that increasing the size adds little to the strength. I can thus make cannon of almost any size, and have no hesitation in saying that mortars could be manufactured large enough to bombard Portsmouth from such a distance that the ship firing could not be seen nor the report of the gun heard. Cast-iron, we know, can only make a 32-pounder gun, and no thickness will enable it to bear a pressure of 6 tons per inch once, or 4½ tons per inch often, which would have a similar effect. In like manner it can easily be proved that 9 tons per inch pressure would destroy a cylinder of any thickness of brass. Steel has not yet been made in very large masses, and a wrought-iron 68-pounder even has yet to be made. Now, in monster guns the pressure of the powder must reach 17 or 18 tons per inch. This is the reason that such guns have not yet been made; but it is evident that if a gun can be made strong enough to bear the full pressure of gunpowder confined in it, it can bear the lesser pressure resulting from firing even the heaviest shot or shell with full charges. Now we have made cylinders to bear this pressure; I hold one in my hand that has borne it; the limit hitherto put to the size of shot by the difficulty of getting a gun to fire very large ones is therefore removed, for guns can be made which powder cannot burst.

This limit being removed, the only one which remains is expense; and this, in many cases, will be much lessened by increasing the size of the projectile. Of course, for every purpose the smallest effort should be made which can fulfil that purpose. To kill a snipe we use snipe-shot, to kill a duck duck-shot; but it would be useless to fire snipe-shot at a duck 70 yards off. Equally so is it to fire 32-pound shot at granite walls from ships 800 yards from them. One shot weighing 320 lb. would do more damage than not only ten, but a hundred 32-lb. shot. Experiments should be made to find the smallest shot which can destroy granite batteries as existing at present; and, if such are to be attacked, shot known to be large enough should be used.

Colonel Wilford, in a lecture recently given at the United Service Institution, stated that Portsmouth is to be defended by batteries of heavy guns, and that probably some of them will have a range of 5000 or 6000 yards. These will probably keep at bay any ships coming merely to bombard the town and dockyard with only 13-inch mortars, because their effective range is under 4000 yards. But, if any power did want to bombard Portsmouth without being annoyed by the land batteries, the way would be to use mortars having a longer range; still, of course, the smallest that would answer the purpose. If a range of 6000 yards is sufficient, it would be waste to use mortars ranging 7000; but to use them with a range of only 4000 would be a much greater waste.

Surely it is worth while to inquire (carefully, and putting aside all prejudices) if such mortars can be made; because, if they can, we may as well arm our coast with bows and arrows as with guns of a shorter range than that of those which can be brought against them. Now, I firmly believe that with common iron, scientifically put together, 30-inch mortars can be made to bear charges of powder of about 2 cwt., the shells weighing about 18 cwt. These would range fully 6000 yards, for the resistance of the air would have a retarding force on a 30-inch shell but one-third as great as on a 10-inch shell, because the surface acted on would be only ninefold larger, while the mass would be twenty-sevenfold heavier.

Even if I am mistaken with respect to the capabilities of common iron, there can be but little difficulty in building a mortar to bear even double the greatest strain that gunpowder can produce, if we use some of the iron lately manufactured.

Mr. Howell makes 10-ton plates of a metal whose tensile power is 50 tons per inch. Mr. Holroyd has a metal of which he cast a 12-pounder gun which bore a test very nearly (if not quite) as great as that borne by my 9-pounder. Had Mr. Holroyd's gun been made so that the outer layers could do their share of work, instead of being so nearly useless as the outside of any thick cast tube must be, I cannot believe that it could ever have been burst by gunpowder. Captain Uchatius and Mr. Krupp also have produced a kind of steel-iron capable of great endurance, and others are on the same track. My own opinion at present is strongly in favour of cast-iron for the interior part of a gun, on account of the rigidity of that metal. The material for the outer layers should be chosen on a consideration of the work to be performed by the gun. If it be destined for a maritime fortress, where weight is no objection, common wrought or even cast-iron may be employed.

For a very large mortar (say of 60 inches calibre, to throw a shell of 7 tons 10 miles), the strongest material must be used, and plenty of it; and it must be subdivided into a great number of layers, each to be strained. As mortars are seldom liable to direct fire from the enemy, wire can be employed for their exterior, being easily put on, or even replaced if damaged; but for guns subject to direct fire I would myself prefer a substance less susceptible of injury, even though the exact initial tension be less easily given. A little experience in forcing one slightly conical tube over another will enable us to judge the strain quite accurately enough.

I am aware that many attempts to make monster cannon have failed, and that there is a strong opinion that such cannot be made. Mr. R. Mallet lately made two 36-inch mortars, at a cost it is said of 40,000*l.* One of these was disabled by a charge of 40 lb. of powder, although the full charge should have been 400 lb. I think this breakdown cannot be fairly looked upon as decisive, because Mr. Mallet thinks he can repair the damage, and also generally because nearly all first attempts fail. In this particular instance there were obvious reasons why the mortars should not succeed. These I published in the 'Mechanics' Magazine' some weeks before the first trial. They were (I may say in general terms), that the mortars were made only twice as strong as they could have been cast, whereas five times the strength of any possible thickness of cast-iron was absolutely necessary. I thought it incumbent on me to state this before the trial, because Mr. Mallet's first plan was to make the mortars on the principle I have endeavoured to explain, and the failure I foresaw could therefore have been used as an argument against it by those who did not know that Mr. Mallet had afterwards modified his plans.

As the abandonment of the principle by so scientific a person would be, however, a still stronger argument against it, I must remark that he informed the British Association at its Dublin meeting that he did so only to some extent, and that on account of the difficulty of accurately applying the principle, and under the

* From the 'Journal of the United Service Institution.'

Digitized by Google

impression that he could obtain sufficient strength without the necessary accuracy.

I have little doubt that now he could make 36-inch mortars that would not fail. A first trial on so large a scale in one sense, and so small a scale in another, presented peculiar difficulties.*

Another large gun lately made has not given satisfactory results. The 13-inch wrought-iron gun presented to the country by the Mersey Steel Company, though never fired with more than 50 lb. of powder, is already cracked in the inside, just as was to be expected, partly from the causes I have endeavoured to point out, as creating a tendency in cannon to crack or rather tear in the inside, partly from the outside of such a large mass cooling so long before the inside. The latter circumstance must tell against any system of making cannon in one mass, whether by casting or otherwise; but I conceive that I have already given reasons enough for abandoning such a plan.

The 13-inch gun was made of a long hollow cylinder with sides 6 inches thick. On this were shrunk red-hot rings or cylinders, making up the thickness of metal at one part to 15 inches, under the erroneous impression that thickness gives strength. Had the cannon been left in this state it must have been much stronger than it is; but it was heated to a welding heat at an enormous cost, and with an exercise of mechanical skill which few (if any) other persons could have brought to bear.† The consequence was that the tension which was on the outer parts, in consequence of their grasping the inner cylinder in cooling, was removed, and they are now able only to employ a slight portion of their strength, whereas it is evident that, had the tension remained, they could employ the same force they now can, added to that they would constantly have exerted: a full charge of powder could then have been used. Without these remarks it would be impossible to remove the impression which prevails,—that large guns have been tried and have failed; I am sure, therefore, that Mr. Clay, who manufactured the great wrought-iron gun, as well as Mr. Mallet, will be glad I have made them, because, if my reasoning be sound, the cause of science which these gentlemen have so much at heart will be advanced, while any unsound reasoning can be immediately detected and exposed.

The most important objection to the system of construction I advocate is, that the longitudinal strength of the gun is lessened by it. For mortars this is unimportant, as the longitudinal strain is scarcely perceptible; but in making guns care must be taken to have strength between the breech and the trunnions. If the internal tube be trusted to for this strain, we must remember that it is also to be strained in another direction, and is further weakened by being pressed between the gas of the powder and the superimposed plies of metal. Still a large margin remains wherein we can add circumferential strength without unduly weakening the piece lengthways; for the present cast guns are stronger in the latter direction than in the former in the proportion of 12 to 1.

It may save trouble in considering the question if I here candidly enumerate every objection which I have heard urged against my plan,—

1st. A member of the Ordnance Select Committee feared the parts would not vibrate in unison. The reply is obvious,—if the first expansion does not cause rupture, each successive pulsation being less than the first has less destructive power.

2nd. The Ordnance Select Committee reported in June 1855, that the plan was dangerous, and not worth further experiments, even at my expense, because "the *expansive powers* of wrought and cast iron are different." Now this difference is a positive advantage when the more expansive metal is put inside, as I suggest, cast-iron extending nearly double as much as wrought-iron with the same pressure, so that the extension of the outside which would be due to the exertion of a force of only half a ton if the thick cylinder were of cast-iron throughout, would give a force of double that amount if the exterior be of wrought-iron. However, the use of different metals forms no essential part of my plans, though it facilitates their practical execution.

3rd. After the wonderful success of my 9-pounder at Shoeburyness the Ordnance Select Committee reported that they had known of the plan since 1807, and that it was identical with others. In the note (see below) I have shown how diametrically opposed are my views and those of the advocates of welded wrought-iron guns. The ancient built-up guns and Mr. Dundas's are still weaker than the welded guns, the latter, after the interior has cracked, being in the same condition as the former when new. The Ordnance Select Committee seems to attribute the great strength I gain as due only to the substitution of wrought-iron for cast-iron. Now the outside inch of a cast gun, when stretched say one-sixth as much as the inside, could, if of iron, exert a force of but one ton. The mere substitution of wrought for cast iron would give double the power, the extension being the same (and it cannot be greater unless the inside crack); but I can make the outer inch exert a force of 10 tons by altering its size. The change of metal gives an additional strength of 1 ton per inch, at most,—the change of *size* gives a further addition of 8 tons per inch.

4th. A member of the Select Committee told me after the trial at Shoeburyness that such great strength as my gun showed is not required.

5th. Wire is objected to for guns. With this objection I agree to a great extent; but it does not apply to mortars, and many cases may occur where very light guns would be so useful that the advantages of using wire would much outweigh the disadvantages. Most guns however, I think, would be better if made of concentric tubes, not wire.

The immediate use to which I should like to see my discovery put, is the manufacture of stronger 68-pounders and 10-inch and 11-inch guns. A 10-inch gun could be made weighing about 5 tons, and strong enough to fire solid shot if required. America has adopted an 11-inch pivot-gun, and I think we should keep pace with that power. A 9-inch broadside gun, and an 11-inch pivot-gun might therefore be adopted for some of our steamers; nor would the 10-inch broadside gun I mention, and a 12-inch or even 13-inch pivot-gun, weighing 7 or 8 tons, be too rapid an advance.

If any of our rivers and harbours are to be defended, I would venture to urge the use of very large shell-guns for all situations which a ship can pass rapidly; but, as I before said, I am an advocate for the employment in all cases of the smallest guns which are sufficient to perform the amount of work required.

The mode of construction I recommend is applicable to small as well as large guns. It has been adopted by Mr. Armstrong of Newcastle, who found a mere thick wrought-iron cylinder insufficient to enable him to use the full force of the gunpowder, which he does by forming the bullet larger than the general bore of his gun, so that the time necessary to force it in permits all the powder to burn. I may be wrong, but am inclined to believe some part of the wonderful accuracy Mr. Armstrong has attained may be attributed to the great velocity given to the shot by the enormous pressure which my mode of construction alone renders possible. I should mention that although Mr. Armstrong did not use the plan till some months after I had taken a patent for it, he did not learn it from me.

Mr. Whitworth, of Manchester, has been kind enough to express his faith in the great strength attainable by one method of applying the principle I advocate, viz., coiling steel or iron wire tightly round a brass tube.* Strength can thus be obtained without the slightest danger of rupture from the brittleness of the core. Mr. Whitworth intends also to make (or perhaps by this time has made) a rifle-barrel of pure iron or decarbonised steel, strengthened at the breech by means of steel wire coiled round it with the proper tension, which Mr. Longridge has calculated for him. By using the material in this form, Mr. Whitworth expects to be able to make rifles light enough to fire from the shoulder, yet strong enough to throw a bullet weighing several ounces. The

* Previously to Mr. Mallet's proposal being accepted, I had submitted one to the military authorities to make 16-inch guns at 800*l.* a piece, on precisely the same principle,—some to be delivered in three months. The Butterly Company had most liberally and patriotically offered to make these at this price, although they estimated the cost price of the first few guns at 3600*l.* each. My proposal was declined on the plea that it was unusual to entrust an individual with the spending of such a large sum as 800*l.* My impression is that the Butterly Company could have carried out the plan quite as well as any other firm or individual in Europe—probably better; for they had then already made an experimental gun for me, and tried it.

† In the beginning of this century a French company made some cannon for the Emperor Napoleon much on the same plan, though smaller. The Ordnance Select Committee has reported to the Minister of War that the plan is substantially identical with mine; this is however an error, the fact being that the outside of these welded wrought-iron guns does absolutely *less* work than the outside of a homogeneous mass, because the inside being formed of bars laid longitudinally and welded can extend in circumference much (nearly one half) less than if the so-called fibre of the metal were in the direction of the strain, so that the outside (extended one tenth as much as iron can be across the fibre) is only strained one twentieth as much as it might be, because the outer fibres are in the direction of the strain. The difference between such a plan and mine, which would make the outside do sixteen or eighteen times as much work, seems obvious. The methods may be identical, but the 13-inch wrought-iron gun cost 3000*l.*—and I can make one for 1000*l.*: the 3000*l.* one required the highest skill in the world,—but any blacksmith could make the other.

* Mr. Whitworth has since been kind enough to assure me of his faith in my method of making cannon of concentric tubes. He has himself made some experiments which prove the truth of my theory.—T. A. B.

Digitized by Google

recoil must be prodigious, but Mr. Whitworth prevents it from hurting the person firing by a most ingenious yet simple plan.

In bringing my views to your notice I would remark, that before doing so I have considered them for some years, and have subjected them to the test of careful experiment, in which I have been assisted by the advice of Mr. William Needham, late managing partner of the Butterly Company, and that of Mr. Reynolds, their talented engineer. The views of Sir Charles Fox and of Mr. James Longridge, who have both also made careful experiments, coincide very nearly, if not quite, with mine, as do likewise those of Prof. Daniel Treadwell, Vice-President of the American Academy (he read a paper on the subject to that learned body in 1856), and of Dr. Hart, of Dublin. These gentlemen all agree with me as to the remedy to be applied, as well as to the existence of the evil. With respect to the evil itself, viz., the smallness of the assistance rendered by the outer parts of a thick cylinder, I have the concurrence of opinion of all engineers who have ever cast one, and the mathematical investigations of Prof. Peter Barlow and of General Morin. In deeds, which some may think as important as words, part of my plans have also the countenance of Whitworth and of Armstrong.

Although, therefore, such an idea if based on a crude theory of my own must have been regarded as chimerical, I trust that when I now, supported to at least some extent by such competent authority, repeat my firm conviction that mortars could without difficulty be made capable of bombarding Portsmouth, Cronstadt, Cherbourg, or any other such place, from a distance of 5 miles; I trust, I say, that the reasoning on which I base this assertion may be deemed worthy of calm and sifting investigation, for, if artillery one hundred-fold more powerful than any now used can be made, we cannot without imminent danger shut our eyes to the fact.

ST. MICHAEL'S CHURCH, COVENTRY, AND ANSTEY CHURCH, WARWICKSHIRE.

A NEW contract has been entered into, which, when completed, will perfect the repairs and alterations in the north aisle of the chancel and that of the church. We can hardly designate these new works as conscientious restorations, inasmuch as sundry deviations have been made from the originals, chiefly in the replacing of parts of the window tracery which bore evidence of a debased period in architecture, by some of a purer and more consistent character. The north porch, projecting but slightly from the general face of the wall, and ceiled with stone ribs within, is included in the new work. As at present existing it is but a sorry remnant of what it once was, and what it is intended to be again,—the whole of the upper portion having been transformed, and some beautiful windows and panelling, with buttresses and crocketted gables, entirely obliterated. A very curious feature, almost unique, was an external pulpit, attached to the west side of the porch, and approached from a staircase in the angle, whose continuation led up to the roof of the aisle. The doorway out into the pulpit still remains, though of course blocked up, and the floor of the pulpit appears to have been carried on a large stone corbel, or foliated bracket. There were no upright enclosing sides, but simply an iron rail extending across, and let into the jambs of the doorway (as the holes remaining plainly show); the canopy overhead seems to have corresponded in size with the corbel beneath, and to have had rich gables and carving,—the whole terminating pyramidally. It is satisfactory to know that there are ample data for the restoration of these features; for, although they are all cleaned off to the general surface of the wall, traces may be here and there made out, and the outline of the masses is clearly discernible from the differing colour of the stonework where anything has been swept away; while, in further corroboration, an old print, of a century or more ago, is undeniable evidence.

The large east window of this aisle was filled with stained glass a year or two back (by Messrs. Heaton and Butler, of London), in memory of the late Colonel Hood, who fell in the Crimea; and a window of very similar design, in a corresponding situation on the south side of the chancel, has just been renewed, and is about to receive in like manner stained glass, as a memorial to the late General Adams, of Anstey Hall, who fell in the battle of Inkermann. The little village church of Anstey, situate a few miles from Coventry, has lately received an important addition, in consequence of the above lamented event, in the shape of an elegant steeple, 100 feet high, which has been erected at the west end, in place of an ugly and insignificant bell-turret. The new steeple has a square lower story, flanked by diagonal buttresses which terminate in pedestals surmounted by sculptured figures; there is a boldly moulded west door, above which is a niche containing a figure of a warrior in armour. The upper stages of the tower and the spire are octagonal, the former has a handsomely embattled parapet, and small belfry windows on the four principal sides. The whole is of ashlar work, and was very carefully executed by Messrs. Robinson, of Coventry, from the designs of Mr. G. G. Scott, and at a cost of about £500.

THE ARCHITECTURE OF THE THIRTEENTH CENTURY.*

By GEORGE GILBERT SCOTT, ESQ., A.R.A.

IN the two lectures I delivered during the last session, my object was to trace out the development of Pointed architecture from the Romanesque nucleus of the preceding age; to show how far this was the result of constructional necessities and the natural progression of art, and how far it was aided and furthered by external influences; and to illustrate the unity and grandeur of the artistic movement which in so short a time generated an art at once so original and so truly noble. My object on the present occasion will be to give a general sketch of that art when it had arrived at its culminating point,—or rather during that wonderful century through which it reigned triumphant, rejoicing in the full attainment of the object of its strivings, and, proceeding from strength to strength, and from beauty to beauty, filled the countries of Western Europe with creations at once new to art, and in many respects nobler than anything the world had previously seen.

Though it is convenient to classify our mediæval architecture under the heads of centuries, its points of change do not in reality coincide with such a division. It would, perhaps, be nearer to the fact if we classed the last quarter in each century with that which follows: thus, in this country the Norman style would be supposed, roughly speaking, to occupy the interval between 1075 and 1175; the Early Pointed style from thence to 1275; the Middle or Decorated periods from 1275 to 1375, and so on.

On this view of the case a great deal of what I treated of in my last lecture belongs artistically to the present one, and a portion of what I am embracing under the head of the thirteenth century would better go with the fourteenth. As, however, I should wish to be as comprehensive as possible in defining the period of the unimpaired integrity of style, I gladly extend it to the very end of the century, and will not quarrel with those who would dip a little into the succeeding one; for, though I prefer the strength and boldness of the works of the earlier part of the century, the style can hardly be regarded as complete if deprived of the more delicate productions which characterise its close.

In my last lecture I showed how, both in France and England, the last quarter of the twelfth century was occupied in bringing the earlier phase of Pointed architecture from a state of mere transition to one of full development and consistency, and how that the works of this period of especial earnestness in onward striding are characterised by a masculine vigour scarcely equalled at any other stage.

We have now to view the Early Pointed style at the period of the full attainment of its aims, and when its endeavours were rather to amplify and to extend its means than to construct a style.

The thirteenth century commenced under the most favourable auspices for the development of the newly-created architecture. In France both the secular and the ecclesiastical powers were in the highest state of prosperity; and if in England such was not the case with the crown, and we were checked by a bad and mean-spirited king, it is clear that both the barons and the Church were in a state of high prosperity; for from the very opening of the century we find works on the grandest scale to have been everywhere undertaken. Whether in the castle, the palace, the cathedral, the monastery, or the parish church, we find the newly-developed style to have been put largely into practice, so that scarcely a building of note fails to show the impress of the youthful art. Every great church must have its share of it; thus, at

* Lecture delivered at the Royal Academy.

Digitized by Google

Canterbury, though they had just completed the eastern half in the style of the transition, the cloisters were added in the perfected manner. At York again, the choir had been rebuilt in the last half of the preceding century; but the perfected style must have its sway, so the Norman transepts were rebuilt in it. At Lincoln, the transformation of style had commenced under St. Hugh, before the close of the twelfth century, and before 1280 but small vestiges of the Norman structure remained. At Ely, the century commenced with the building of the western porch, which was followed up by the magnificent eastern arm of the cathedral. At St. Alban's, the gigantic Norman church had not been completed much more than half a century before its western façade was demolished and recommenced in the new style, in which one-half of the nave partook; and before the thirteenth century was finished the choir had also been rebuilt. At Durham, the Norman church received the magnificent addition of the Chapel of the Nine Altars; at Fountains a similar addition was made, with an entire new choir, and many noble appendages. Wells Cathedral was almost rebuilt in the new style; indeed, it is scarcely possible to single out any great church which does not more or less evince the influence of the great architectural movement which ushered in the thirteenth century. Its most complete work is the cathedral at Salisbury; and among its later creations we may enumerate the eastern portion of Westminster Abbey, the whole of Tintern Abbey, and nearly the whole of the once sumptuous church of St. Mary's Abbey, at York; while its last decade produced some of the most exquisite gems of art, such as the Tombs of Cruchbach, of De Luda, and of Archbishop Peckham, the chapel of Ely-place, Holborn, and the Eleanor Crosses; so that, taken as a whole, the century can claim most of the noblest, as well as of the most elegant, productions of English art.

In France its pre-eminence is if possible yet more manifest. The century opened there under the fully established power of Philip Augustus, the most powerful monarch who had ruled France since the days of Charlemagne. In the days of his predecessor the English king had governed more French provinces than the King of France himself; but now the English were almost entirely expelled, and this mighty monarch reigned without a rival. In his days commenced an almost general rebuilding (wholly or in part) of the cathedrals, excepting such as were of very recent date. The west façade of Notre Dame at Paris, the greater part of Rouen, of Rheims, of Amiens, of Coutance, of Bourges, of Le Mans, and a list far too long to be enumerated, owe their grandeur to his reign, or immediately following. Towards the middle of the century the same work progressed gloriously under the auspices of St. Louis, and though slackened from actual satiety towards the close of the century, it was not really checked till the commencement of the English war.

As in England, the works thus produced evince masculine grandeur of the highest order at the commencement, and the most delicate beauty at the close of the century, while during its middle portion the two are united in the works of St. Louis.

In Germany the works of this century evince great artistic disturbance. The change from the round to the pointed arch style had been there resisted, while both in France and England it had been worked out to maturity. At the opening of the century German architecture consisted of a highly refined variety of Romanesque, with the partial use of the pointed arch, chiefly where suggested by constructional necessities. This during the first quarter, or more, of the century developed itself into an Early Pointed style, strictly German, and holding out promises of great force and originality,—promises which were frustrated by the sudden inroad of French Gothic about 1250, after which, though Germany took a course still very much her own, it was one in a great degree severed from her noble early tradition, and emanating from the French graft rather than from the original stem.

Italy received her Pointed architecture from France and Germany, and mingled it freely with her Classico-Lombardic traditions. The union produced many noble and many incongruous developments. The lessons they offer must be used with caution; but Italy being the land of ancient art, the land of sculpture, of painting, of rich marbles, of mosaic work, and of municipal and other civic edifices, the graft of northern art upon so prolific a stock has, as may readily be imagined, produced varieties which the circumstances of northern nations would have rendered impracticable in its native lands; and the suggestions they offer, if judiciously used, are well calculated to add copiousness to the style in the hands of its modern revivers. Of this I may have occasion to say more hereafter.

The thirteenth century was to the mediæval art what the Periclean and Augustan ages were to the Greek and Roman; and in each case, though war and bloodshed are in themselves hostile to art, there can be no doubt that the excitement of the human mind, resulting from great national struggles, have tended to produce that advance in art which followed, in one case the glorious assertion of national independence; in another, the conquest of the world; and in a third, the romantic and unselfish efforts of the Crusaders.

It was a period of deep-seated mental excitement, of a prodigious upstirring of the human intellect. Our learned men at the present day may smile at the quaint and imperfect erudition of these early periods of our civilisation, but they should remember that they were our days of youth, of warmth, and of rising vigour, while the more perfected literature of our own age may possibly be found to superadd to its maturity a few symptoms of old age.

This youthful energy pervaded every branch of art; everything seemed to experience a new, a generous, and a vigorous impulse. All Europe became filled with the productions of the newly generated art; every city became a repertory of noble and sublime architecture, and every town and village became possessed of productions equally beautiful, if more modest in their pretensions; while the intervening country was studded over with castles and monastic establishments, in which the same majestic art displayed itself in ever-varying forms, each suited to meet their different requirements.

Nothing is more difficult than to describe a perfected art. My last two lectures traced out the gradual construction of Pointed architecture, and its transition from the preceding style. This was comparatively easy; but to describe it when it had attained perfection is far less so.

The fact is that there is neither in France nor in England any marked difference between the styles during the later period of its transition, and when perfected beyond that unity and consistency of parts which indicate maturity. In France particularly this is the case; for neither had the style there continued long to evince its transitional state by the retention of strictly Romanesque features—unless the square abacus can be so designated—nor did it when perfected throw off, as in England, that one detail which to our eye seems a relic of transition. The later transition and the earlier perfected specimens seem in France to be the same art, a little more developed and more homogeneous, rather than to have many describable points of difference. In England the change of the abacus from the square to the round form makes the distinction more marked, so that English examples at the opening of the thirteenth century always appear later and more advanced than contemporary French ones. I instanced in my last lecture four examples of perfected Early English: the eastern transept of Lincoln, completed about 1200; the eastern chapels at Winchester, about 1204; the western portals of St. Alban's, finished about 1205; and the western porch or Galilee at Ely, finished about 1214. None of them show any remains of transitional character, and all having the English round capital in full development, appear to the English eye more advanced than such works as the western portals of Notre Dame, at Paris, which are, if anything, somewhat later in date. In this country in fact the form of the abacus is the distinguishing feature between the transition and the perfected style, while in France there is no such distinction to be found. The difference is more one of feeling, which the practical eye perceives at once without being able to define.

Though I speak of the Early Pointed as a newly generated art—as it in effect was—it must never be forgotten that it is a distinct and natural growth from the pre-existing Romanesque. The more I study old examples the more obvious does this appear. Take either France or England alone, and you may from either construct *ad libitum*, unbroken catenæ of examples, showing step by step the natural and logical growth of the new style out of the old; and that without any essential imported element (for the Byzantine capital, which was the parent of the Gothic one, was an accidental though a happy importation.)

This progressive growth was but the practical realisation of three great aims towards which the Romanesque architects were ever striving,—the perfecting of their arcuated and vaulted construction, the increase of the altitude of their proportions, and the general adding of refinement and elegance to their details. Thus, if you take the internal bay of a Norman cathedral, and simply set yourself the task of increasing its height in a given proportion,

Digitized by Google

the result will be a Gothic bay, for the arches cannot participate in the increased elevation without becoming pointed. If the details are further refined it becomes an ordinary transitional design; and if the process is carried on a little further it becomes a perfected Early Pointed work. The distinction between transition and perfected Early Pointed being merely the carrying on of the process by which the former was generated out of the Romanesque. This fact, which all who look closely into it must see, was what led a talented writer to say that Early Pointed was only Romanesque improved. He meant this as an argument against it as compared with the still succeeding styles; but I confess, for my own part, while feeling strongly the truth of the observation, and highly appreciating the importance of some of the subsequent developments, I do not the less admire the glorious productions of the early style from seeing in them the evidences of the vigorous stock from which they have sprung.

It will be seen, by enumerating the leading characteristics of Pointed architecture, that the great majority of them were already perfected, or at least brought to that reasonable and consistent state of development which stops short of excess and exaggeration at the commencement of the thirteenth century.

The pointed arch had obtained universal predominance, though without involving the rejection of the semicircular or the plain segment, where circumstances called for them; the general predominance of the vertical line was acknowledged, without running into the excess of underrating the horizontal; lofty and aspiring proportions prevailed, though not to the extent of exaggeration, and without unreasonably asserting their claims in works of a humbler class; the subdivision of arches into orders, and the clustering of the pillars, so as to satisfy the eye that each member of the arch was severally supported, had arisen during the Romanesque period, and was now carried out still more systematically and with greater elegance; and the system of making the bases and capitals face in the direction of the insisting arch-rib, which had also arisen early, was (in France at least) very generally adhered to. The distinction between constructional and decorative pillars—one of the great characteristics of the Gothic style, both round and pointed—was carried to its fullest extent; the vaulting system was perfected, though retaining its normal simplicity; and the corresponding system of buttress (solid or arched) and pinnacle, which are the necessary accompaniments of a perfect arcuated style, had been brought to perfection; the continuity of line was acknowledged sufficiently to suggest a feeling of natural growth of the parts one from another, from the bases of the shafts to the bosses of the vaulting, but without that sacrifice of force and of all salient points which became the vice of later styles.

The principle of rendering the useful features ornamental was fully developed: as an instance of it, the doorways, the only parts of the exterior which must of necessity be seen from close at hand, were rendered magnificent beyond all former precedent, and became the vehicles of noble sculpture, and the great exponents of the objects of the building, whether religious or secular. The windows now became great characteristic objects, not only from their richly painted glass within, but as leading architectural features both within and without. The bell towers became glorious structures, rendering the cities conspicuous throughout the whole surrounding district, and making every village a distinct and beautiful point in the landscape. The same principle obtained in all the secular structures. The castles of the nobility became truly noble structures, glorious for the stern grandeur of their external aspect, and for the massive beauty of their internal architecture; the gates and defences of cities partook of the same severe grandeur; while the street fronts, the town-halls, and other civic buildings displayed architectural characteristics, modest or grand, as suited their several purposes. In Italy, where municipal institutions were more developed, noble street palaces were erected; and everywhere the architecture, whether viewed in the mass or in its details, was suited, as by an unerring instinct, to the objects on which it was exercised.

The decorative system of the architecture had also been brought to great perfection. The mouldings were refined without losing boldness or strength,—in fact, were strong or delicate as suited their position; the foliated carving had arrived at very high perfection, and was of a kind perfectly new—the magnificent creation of the artistic mind; sculpture was often profusely used in connection with architecture, and if not of that perfectly studied symmetry which satisfied the academic critic, it evinces a boldness of conception, a quickness of invention, and an unaffected grandeur of sentiment, which our modern sculptors would do well to emulate, while it is eminently suited, by its rigid lines and severe force, to architectural purposes.

It would be absurd to attempt in a single lecture to give any detailed description of the architecture of this great period; nor is it necessary, as no style is so familiar to those whose attention has been at all turned to such subjects; I will, however, take a few of its leading points and call attention to some of their characteristics.

I will begin with the Column. In no feature is the difference between Classic and Gothic architecture so strongly marked as in the column. In the former one general ideal alone prevailed,—the round shaft with a capital, and with or without a base. In the latter this normal type is equally admissible and equally honoured, but in addition to it an almost endless list of forms are introduced. In the first place the round column is converted at pleasure into the octagonal or other polygonal form,—this is a mere variety of the normal type; then either the round or the polygon is flanked by four smaller shafts, attached or detached, and these subsidiary shafts may be increased in number, subordinated one to another both in size and saliance, and may be all attached, all detached, or the attached and detached shafts may be used alternately, or in any other order in the same pillar.

Then again, instead of the cylindrical pillar, we may have four cylinders united in one, and these may in their turn be made the nucleus round which detached or attached shafts may be grouped; or we may have two or more separate cylindrical main shafts carrying the load, and may group subordinate ones round them; and again we may take other forms of nucleus, as the square, the canted square, or a pier with receding orders, and place our shafts round them; and finally we may form groups in which no specific form of nucleus is to be traced, but which consist of shafts arranged with reference to the superincumbent arch alone.

The number of changes which may be rung on these varieties of pillar are absolutely endless, though it is not desirable to indulge too much in the more intricate forms of grouping; but, as a general rule, to keep to forms which are naturally suggested by the duties the pillar is designed to perform. When detached subsidiary shafts are used it is somewhat unnatural to joint them in their length without introducing some visible means of tying them to the main pillar within. This necessity gave rise to the use of the moulded band, which forms so beautiful a feature in the pillars of this period. It is sometimes made of brass, but more usually in stone or marble.

The bases of columns throughout the Romanesque period were most usually founded on some traditional variety of the attic base. The resemblance is often obscure, but in many cases very close.

Towards the end of the Romanesque period very great attention began to be paid to the sections of base mouldings, and in transitional works they are often more beautiful than at any other period. The difference between these bases and the ordinary attic base is of the same kind which distinguishes Greek from Roman moulding. It is an extreme delicacy of curve, the substitution of elliptical section for circular, and a wonderfully studious grouping of the hollows, rounds, and arrises, so as to produce a refined and delicate contrast and gradation of light and shade, without destroying the strength necessary to the main supporting feature. In this they showed a high appreciation of what is in all architecture a difficult problem,—the uniting the conflicting claims of the lower part of a building, as on the one hand demanding the greatest strength of character as supporting the whole structure, and on the other a delicate finish, as the part open to the closest inspection.

The bases have usually one more part than a Classic base, having in most cases a projecting sub-plinth, either chamfered or moulded. In earlier instances the plinth and sub-plinth are both square in plan; and here, again, we obtain a feature of great beauty, which antique architecture did not possess. I mean the beautiful leaves or bosses of foliage which spring out of the lower torus to cover the projecting angles of the plinth.

This projection is often reduced by making the torus overhang the square plinth in the centre of its sides, and a little projecting corbel is often put to carry this overhanging, as well as the leaf to cover the angles of the plinth.

At a later period the square plinth gave way to the octagonal, and in England and Normandy often to the round form.

In the early work the bases often faced about diagonally, as the caps, to indicate the direction of the arch-ribs to be supported.

Digitized by Google

In France the elliptical section of the lower torus continued much longer than in England, and the upper torus was often converted into a kind of ogee, and both in France and England the scotia was usually very narrow and deep,—so much so, indeed, as to hold water. In England another kind of base is frequent, in which a bead is substituted for the scotia. In some rich work the plinth is clothed with foliage.

I have said a good deal of the history of the capitals of the Early Pointed period in my last lecture. I particularly showed that about the period of the transition a great change took place in France in the form of the capitals, in which the old Romanesque form was almost universally abandoned in favour of one of a distinctly Byzantine origin, which I suggested came in all probability by way of Venice, at the time of the erection of the Byzantine churches in Aquitaine; and that though the domical construction of churches then brought into France does not appear to have extended northward of the Loire, the Byzantine capital of the Corinthianesque type was adopted quite into the north of France, and became the parent of the exquisite capitals and foliage which in the next generation pervaded the architecture both of France and England, and a little later of Germany. I also showed that the peculiar stalk or crocket which became so constant a feature in Early Gothic capitals, took its origin from a plain unraffled leaf frequent in the Byzantine capitals, which in their turn may have been suggested by unfinished leaves, which are of very common occurrence in the capitals of that period.

During the first half of the thirteenth century these crocket capitals were brought to very high perfection, the stalk or crocket either appearing in its most normal form, or being more or less clothed and concealed by foliage. In the latter case it forms a strong background to the leaves, giving them the apparent stiffness and strength necessary to their position. These usually turn over in a bunch of foliage, which is distinct from the leaves which clothe them; so that there is no inconsistency, but the reverse, in the clothing foliage being natural, while the terminal bunch which completes the crocket is conventional. Towards the middle of the century the natural and conventional foliage were very much used together, the former being often a light playful overlaying of stronger leading forms; but afterwards in French work, and still later in English, natural foliage became the rule, and conventional the exception.

The capitals which prevailed during this century form the most magnificent series which any style of architecture can boast. Whether the foliage is natural, conventional, or both united, the artistic power evinced is truly delightful; and when it is recollected that no two capitals are ever found exactly alike, the fertility of invention they display is perfectly wonderful.

It would be hopeless in such a lecture as this to attempt to go through, even in the most cursory manner, the endless varieties of capital,—from the stupendous masses of noble foliage which crown the apsidal columns at Rheims, whose single shafts are 6 feet in diameter, to the delicate reeds which decorate the mullions of windows. This one feature alone would form an ample subject for an entire lecture, or almost for a series of lectures. I will confine my present remarks to the great characteristic differences which distinguish French from English capitals during the thirteenth century.

This great distinction lies in the plan of the abacus: for while in France the square form of the preceding style continued, the English architects very soon substituted the circular plan. It is a curious question how and when this arose. In both countries the round abacus was in some instances used from an early period; but this was chiefly on great cylindrical columns with low capitals, such as those in the nave at Gloucester Cathedral; though even in France the round form occasionally occurs to subordinate shafts, as at St. Omer; but, as a general rule, both countries used the square or the angular form till late in the transition, when the English commenced the free adoption of the round, first alongside of the other, and afterwards to its almost entire exclusion.

So early as the erection of the crypt under the Trinity Chapel at Canterbury, by William the Englishman, about 1180, we find the round moulded capital; and in the altar recesses in the eastern transept we find the round abacus on foliated capitals, though I confess I doubt its belonging, in this last mentioned instance, to the original work.

Much difference of opinion now exists as to the comparative merits of these two forms. By some the square abacus is assumed to be the great symbol of force and vigour; while, by others, it is said to be inconsistent with the true principles of Gothic architecture. Perpaps the question might be solved by deciding that both are beautiful, both vigorous, and both consistent with Gothic architecture, and therefore that both should be admitted on equal terms as portions of our general material.

The advantages of the angular abacus are,—that it allows of the capitals indicating the direction of the arch-ribs, and assuming irregular forms suggested by them, which the round form forbids; that it allows of the use of square orders, and consequently of simpler and more effective arch mouldings than can be placed in the round abacus, on which the mouldings have to be somewhat crushed in their section, and their parts multiplied, to bring then nicely on to the round support, and that the angles indicate the direction in which the main stalks of the foliage should tend. There can be no doubt, on the whole, that it produces the most vigorous effect; and I must plead guilty to an un-English preference for it, though I also greatly admire its competitor, whose advantages are the beautiful form which the round moulding takes as seen in perspective from below, and its less disturbance of the continuity of line.

Another great characteristic of English architecture is the moulded (unfoliated) capital. This is almost wanting in French architecture, and I strongly contend that the invention of this capital, which we may almost claim for our own country, is one of extreme value, and supplies what would be otherwise a great hiatus in the style. Among its earlier instances is that I have already mentioned in the crypt at Canterbury. It is there in rather a plain and normal form, nearly resembling a capital denuded of its foliage, but with the space below the abacus and the bell somewhat increased for the sake of strength. The fully developed moulded capital differs from this in having a considerable overhanging moulding, which is the substitute for, and the representative of, the foliage of the richer capital. Though this overhanging moulding is uniform in type, the varieties it assumes in detail are endless, and the groups of mouldings in these capitals are among the most beautiful in the whole range of Gothic architecture, and the addition of this beautiful feature to our rich treasury of forms of capital is of infinite value.

The abacus of the moulded capitals is not necessarily round. There are many instances of its being square, and still more of its being octagonal,—a form in which it continued through the later periods of English architecture.

I ought to have mentioned that in its normal condition the abacus is in a separate stone from the rest of the capital, though convenience frequently suggests its being in one. When marble shafts however are used, it is far better that the same material be used also for the abacus.

Next in importance to the column, as a characteristic of the style, we must place the Window. Indeed, it has generally been made to take the precedence of it, and is no doubt that by which the date of a building is most readily ascertained, and its style defined.

The Romanesque windows were simply openings with round heads, the jambs and arches being either perfectly plain, moulded, with or without enrichment, or the jambs shafted. These windows were most usually isolated, but were here and there grouped into couplets, triplets, &c., or made to form portions of continuous arcading.

In the early days of the transition the windows remained unaltered otherwise than as to the general refinement of their details. Later on the arches were made pointed, and their proportions somewhat elongated; and even in the fully developed Early Pointed style—properly so called—the window differs little in principle from that of the Romanesque period, though in fact it assumes a widely different form, through its carrying towards their ultimate results of the principles of grouping began during the previous styles, and those of refinement and elongation incident to the transition.

It is in carrying out these principles to a still greater extent that the Early Pointed of England differs from that of France. It is really the same style, and no important feature can be pointed out in the one country which is not to be found in the other; but just as the Germans, by dwelling longer on the Romanesque style, rendered it more refined and perfect than elsewhere, the English, by the continued retention of the unmullioned window, systematised its use in a manner not equalled in other countries. I see no difference of principle in the fenestration of the Early French and the Early English Pointed styles: in both the principle was the decoration and combination of single lights.

Digitized by Google

Nor do I see that in England this was done in a manner essentially differing in any respect from what was common in France. The great difference was the far greater width of the French openings, which often rendered their windows inelegant in proportion, while it offered a noble field for stained glass. The characteristic of the English windows, on the other hand, was narrow and tall proportions, and a greater amount of enrichment of the jambs and arches, though none of these are by any means constant features. Sometimes we find in English works lightness carried to a vicious extreme, as in the beautiful but frail eastern transept at Worcester; though in the majority of instances it retains a masculine firmness and solidity, as in the east end of Whitley.

Time would fail me to illustrate the magnificent combinations of this early class of window to be found in cathedrals and monastic churches,—as the east end of Ely, the west at Llandaff, or the north transept at York; nor would it be possible to enumerate the simple and impressive village churches to which, in their humbler forms, though with equal artistic merit, they lend such a charm. The style is too well known in England to need minute description, and its merits too fully acknowledged to need enforcement from me.

I will rather proceed to consider that great invention which may be considered to complete the series of developments which constituted Pointed architecture: I mean the mullioned and traceried window; not that I consider it as in all points better than its predecessor, nor that in our own revival it should supersede it; but that, as a matter of fact, Gothic architecture would have been imperfect without it. Like almost every other feature of Pointed architecture the traceried window grew out of the Romanesque.

In all periods of Romanesque we find occasionally two or more arched openings comprised under one enclosing arch. This arrangement is more frequent in belfry windows and triforium openings than elsewhere, but occurs in ordinary windows, especially in secular buildings. The space intervening between the large arch and the two or more placed below it was, even as early as this, occasionally pierced with circles or other forms of opening. Here, then, we have the elements of the mullioned window before even the introduction of the pointed arch. In the same situations it gradually developed itself, step by step, during the Early Pointed period, so that we have in triforium arcades and in other positions a pretty full development of what is called plate tracery, before its use became frequent for ordinary windows. The case was pretty much the same both in France and England, though on the whole the love of placing two openings under one arch was greater in France; thus we see in the aisles at Chartres two plain lights under one arch with a circular opening, and above, in the clerestory, a very large circle with somewhat complex subordinate piercings. The same is the case at Bourges, where three lights are often comprised under one arch, with a single circle in the head.

The next great element which aided in producing tracery windows was the wheel, or other richly-pierced circular window. This again originated under the Romanesque style, as we may see at Barfreston and elsewhere. It is, in fact, a very close approach to tracery, and when placed in the space between comprising and comprised arches, it almost completes the change. All that is wanted is the piercing of the intervening spaces in forms whose outlines are parallel to the main piercings, so as to form what Prof. Willis calls bar tracery. This was, I fancy, commenced in France—though there are very early traces of it in England—and was done at first in a partial and clumsy manner, as in some windows at Le Mans and Tours, but soon was systematised.

I do not see that in any of the previous steps the French were in advance of the English architects, but in this last step I think they were so, and this led them to a much earlier abandonment of the single window and its combinations; so that for some time the French were using tracery windows while we were rendering more perfect the unmullioned system,—not from want of knowledge of the other, but rather preference for a system in which we were producing more beautiful combinations than our neighbours had attained.

It is not a very profitable question to inquire by how many years the French may have been in advance of us in this development, and it is so exceedingly difficult to get at positive dates of the erection of buildings in either country, that it would be impossible if desired. The fact, no doubt, is that for many years the two kinds of window were contemporaneous. Thus, traceried windows may have been in use at Rheims and Amiens, while the older kind was being used at Bourges and Chartres.

It is said that in England the fully-developed bar tracery was first used in Westminster Abbey, which was commenced in 1245; but this is merely an assumption: and it is clear that it was used in the eastern part of St. Paul's, a part of which was consecrated in 1240. The east window of Netley Abbey looks very early, but I do not know its real date, but believe it is said to have been finished in 1249, while the eastern windows at Lincoln look too thoroughly developed to be very early specimens, though known to have been erected between 1250 and 1280. In any case the change had fully established itself in England during the third quarter of the century.

There can be no doubt that whichever class of window we prefer, this invention was of immense practical utility. It rendered possible what was never obtained before,—the formation of windows of any width which might be wanted without injury to the beauty of the building. This is in fact the great use of the mullion—to enable you to use wider windows than you could use without it,—indeed, to render their width unlimited; and the consequence of the invention was the introduction of windows in some cases not less than 30 feet or more in width, and 60 or 70 in height, and that without appearing to make any unseemly gap in the walling, which would otherwise have been the case with a window of one-sixth of the size.

After the system was once introduced it seems to me to have been often more beautifully carried out in England than in France; indeed, I hardly know in France windows of equal beauty with those at Lincoln, Tintern, or St. Mary's Abbey at York.

At a later period excess of tracery became the great vice of the style, but while kept within bounds it unquestionably was a great element to its perfection; and though it must always be remembered that a building of any amount of beauty and dignity can be designed without it, it would be placing upon ourselves a very foolish restriction if, merely from an individual preference for the earlier and sterner style, we were to debar ourselves from the use of so convenient and reasonable an element.

One feature in which the English works of this period appear to me to be peculiarly excellent is the base moulds; I do not mean of columns, but of the building itself. I have never seen any in France to equal many of our own in the quality of appearing eminently fitted to support the whole structure, or in the artistic arrangement of their parts.

Against this we may balance on the other side the French cornices and foliated bands, which are one of their most beautiful characteristics. They usually consist of two courses—a hollow projecting moulding containing the foliage, capped by a weather moulding—the equivalent respectively of the bell and abacus of the capital; indeed, in many cases forming the continuation of the capitals of window jambs across the intervening piers. We have in many cases cornices equivalent to these,—as at York, Howden, and the nave of Lichfield; but they are on the whole a much less English than French feature. The foliage they contain is usually of great beauty, and eminently suited to its position.

The great glory, however, of the French churches is their doorways; and beautiful as are those of our own, they make no kind of pretension to vie with those of our neighbours in magnificence. In this respect the architects of the two nations seem to have gone on quite contrary principles; for the French, even in buildings on a secondary scale, introduced portals of prodigious size and extreme richness, while the English, even in buildings on a grand scale, often made their doorways very inconspicuous. Compare, for instance, the façades of Amiens and of Wells: in one the portals are everything, so that you can recollect little else; and in the other they are nothing, and you can scarcely recollect their existence;—while in the façade above the English example is the richer of the two; and the illustrative sculpture, which in the one case is expended on the portals, is in the other diffused over the entire front. In England a magnificent portal is of rare occurrence; in France one looks for it as a thing of course. Nothing more glorious than the great French portals can be conceived: the lofty and deeply-receding jambs are divided in their ample height into two portions, the pedestal or basement of which is richly decorated either with diaper-work or with sculptured medallions, or, as at Amiens, with both; and the upper stage contains colossal figures of apostles or other holy men of old, who appear to view with severe and solemn benignity the entering crowd, and to express, by the gravity of their counte-

Digitized by Google

nances, the caution, "Keep thy foot when thou goest to the House of God." In the tympanum are sculptured scenes from scripture history, the lives of saints, our Lord surrounded by the evangelistic symbols, or perhaps the awful scenes of the final Judgment; and the mouldings of the arch are probably filled with angelic figures, as if the guardians of the faithful worshippers; while this impressive array of imagery is placed in a setting of the noblest and most perfect architecture, and that on a scale well suited to the sublimity of the sentiments expressed.

The portals of Notre Dame at Paris, of Amiens, and of Chartres, may be instanced as among the most striking examples; but all great churches of the end of the twelfth and of the thirteenth century have the same truly glorious approaches, well calculated to solemnise the minds of those entering by them, and to prepare the way for the overwhelming dignity of the interior.

The nearest approach which we have in England to this class of doorway is the south entrance to the eastern part of Lincoln,—a truly noble portal; but on the whole, though of a different class, the most dignified approach to any English cathedral is the western part of Ely. St. Alban's has had three magnificent western entrances. The smaller ones have been wonderful works of art, though now ruined. The north porches of Salisbury and Wells are very noble; indeed, many of our great churches have portals which we should deem magnificent could we forget those of France, and what we know to be eminently beautiful, however they may be supassed in magnificence.

In almost all other parts the English cathedrals of this age are often richer than the French, as in the clustering of the columns, the richness of the arch mouldings, the beauty of their wall arcading, the importance and detail of the triforium, &c.; while, on the contra side, they have to yield greatly to the French in altitude; and in many cases in general scale, as well as in the amount of sculpture with which they are enriched.

My object in drawing these comparisons is not a wish to lay any claim to superiority for either, nor to shake the claims of our neighbours to general precedence, as I view Paris to be, in a certain sense, the centre and metropolis of mediæval art. It is rather to show that these were the arts of a great period, not of a single people; that all were labouring together in perfecting a great and glorious development of art, each knowing well what others were doing, each according to their means taking care to keep up to the standard already attained, and to add to the public treasury developments of their own; each making it his great endeavour to do his own work as well as it could possibly be done according to the means at command, and each people vieing with its neighbours—not in the spirit of petty jealous competitors for praise, but each striving with a noble and glorious emulation to do the utmost in its power to further the great art which all had contributed in generating.

Having given in this and my two preceding lectures a rough and very imperfect sketch of the rise and perfecting of Gothic architecture, it is not my intention any further to pursue the subject historically; but, assuming the thirteenth century to be the great period of the style, I should wish in any future lectures I may give to illustrate and discuss its principles, and the many sections into which it divides itself, whether geographical varieties or the leading features of the buildings themselves. I may not be able to carry out this intention, but in the one lecture I hope to give next week, I purpose—after alluding to some of the most remarkable works of the period, and with some slight description of their characteristics, and after calling attention to the all-prevailing character of the art as it bore upon secular and other buildings, upon the allied arts, and upon the ordinary arts of common life,—to found upon what we have had in review before us some general suggestions as to the practical lessons we ought to learn from what we have been considering, and the influence it ought to have upon our own artistic practice.

RICHMOND CHURCH, YORKSHIRE.

The restorations commenced a few months since at this ancient structure are proceeding satisfactorily. In the course of the work several old features, which had been either concealed or almost effaced, have been brought to light, and illustrate the history of the building in a much more complete manner than might have been expected. Portions of the chancel which have been disclosed by the removal of the vestry indicate Norman features; and, in particular, the buttress enclosing the north-east angle, which extends on both the north and east sides to a width of 3 ft. 6 in., and having a uniform projection of only 9 inches from the face of the wall. Six feet to the west of this buttress, and at the north side of the chancel, there is the lower part of another buttress of a similar character, which was entirely hidden by the vestry. This latter buttress is also 3 ft. 6 in. wide, and projects 9 inches. No doubt, like most other buttresses of that period, it would run up to the height of the side wall of the chancel with the same projection, and finish under the cornice. The string-course also that crosses the east end has run round this side of the chancel, though it must have been roughly broken off when the vestry was built. Between the buttress at the angle and this side buttress was a Norman window, and it is probable that there were at least two similar Norman windows at the east end of the chancel, before the insertion of the present Perpendicular window; and that the buttress now at the east end below the large window, not terminating at the string course, formerly ran up to the cornice upon the wall at that end of the church, with one window on each side, between it and the angular buttress. Probably there would be a similar window on the south side of the chancel, opposite to the one discovered on the north side, and this would give uniformity to the whole exterior of the chancel. These Norman remains at the east end satisfactorily prove that the first church was the full length of the one now undergoing restoration, though its aisles would not be so wide as the aisles in the present church.

ON THE PAINTING OF THE ANCIENTS.

By F. P. Cockerell.*

(*Concluded from p. 44.*)

The assumption that as art progressed colour became considered second in importance to form, and so was less used, is in a measure borne out by the experience of other schools; and though it would be a bold theory to advance that perfection of form and perfection of colour cannot coexist in a work, still we find practically that they do not except in rare instances. This is exemplified in many instances in painting, and particularly in the works of the Venetian school. There can be no doubt that in sculpture strong colour detracts from the value of form in the portions so coloured. Who can walk through a sculpture gallery without being struck with the apparent want of modelling in works executed in coloured marbles or in porphyry? Many instances of this fact will be familiar to those who are acquainted with our own and foreign galleries. We always find in well ordered museums that by the side of a gem, whether intaglio or cameo, there is a cast in plaster, without which it is extremely difficult to distinguish the beauty of execution. This subject may be further illustrated by the converse, as exhibited in the works of the school of the seventeenth century. Bernini often expressed in marble minute forms, such as the veins, &c., which in nature are scarcely noticeable except when marked by a difference of colour. In white casts from the life, of a woman's hand for instance, one is shocked by the coarseness of the skin, which appears so smooth and delicate in nature.

In architecture the disposition of lines and forms in colour of course materially affect the moulded forms, and may be in direct contradiction to them. The bird's-mouth moulding as it is usually painted, becomes a leaf moulding. Many antiquarians insist upon painting an egg-and-tongue ornament upon the echinus of the Doric cap. One of its chief charms seems to be the beautiful combination of the circle in perspective with the sectional curve of the echinus, and this is entirely disguised by the cutting of painted lines (in direction of the sectional curve) upon the horizontal circle; and a quarter-round, or any other clumsy curve, would answer the purpose almost as well.

The opinions of learned authorities upon the colouring of the Parthenon, the temple of Theseus, and other works of the best times are so opposite, and there has been so much learned argument in support of each view, that it is impossible to lay down with certainty whether they were or were not highly coloured, as many of the Sicilian temples undoubtedly were. But the opinions of some excellent authorities, and certain obvious arguments, which in their learned disquisitions are perhaps not sufficiently weighed, seem to point to a very sparing use of colour in exteriors.

* Paper read at the Architectural Museum.

Digitized by Google

For the many elaborate arguments of learned antiquaries I refer you to M. Hittorff's book, which very candidly gives both views of the question, as we have not space here to go into them. There are one or two simple arguments, however, which go a long way to prove the sparing use of colour. First, that one so constantly advanced,—that the material being white marble, very difficult to work, and obtained at a great expense, it is highly improbable that its beauty should be obscured by the general coat of paint sought to be proved by M. Semper and others. Mr. Penrose—a recent and most conscientious investigator—finds no other traces of colour than those given in this book; and he uses the apparently conclusive argument, that if it were intended to colour the Parthenon all over, the marble of Hymettus would have been used instead of that of Pentetieus, the former being much easier of access, the quarries sounder, no difficulty in obtaining large blocks; but the objection being apparently that the marble is of a grey colour. Another instance of the pains taken to procure a fine white marble is the temple of Delphi, which, being built of stone, was faced with Parian marble, brought from a great distance. It is very possible, and indeed probable, that the blazing white of the fresh marble was toned by means of a light warm dye.

Plutarch mentions a temple of Diana Orientalis, in the island of Eubœa, round which "columns or styles of marble were erected which had the smell of saffron, and assumed its colour on being rubbed with the hand."

Pliny says, "at Elis there is a temple of Minerva, in which Panœnus, brother of Phidias, covered the coating of the walls with milk and saffron, of which one perceives the smell even now when one rubs it with the wetted thumb."

Mr. Penrose in his book states that there are remains in some portions of the Parthenon of mediæval painting; and is it not perfectly possible that the embellishments of churchwardens in this, and in other monuments subsequent to the age of Pericles, may have misled those who take the extreme view of ancient polychromy?

Those ornaments of which there is no reason to doubt the authenticity are generally very small and delicate, and are sparingly used. The soffits in particular seem to have been coloured, and especially the coffers inside the portico. It is highly interesting to observe—and this is a point of vital importance in practice—that, while the architectural parts and features are marked and distinct, the ornaments painted upon them are so small and delicate that the eye has some difficulty at first in deciphering them. It is a common error to suppose that boldness and character consist in making all the parts—those which are subordinate, as well as the leading features—distinct and clear, so that the whole comes down upon the eye. But these considerations are not necessarily anti-polychromatic, for in these liberal times no one will venture to deny the advantage of colour under certain circumstances, and let us endeavour to understand what may be those circumstances.

Many of us have seen the happy results of Mr. Gibson's efforts in the application of colour to sculpture. He founds upon his persuasion of the practice of the Greeks his system of a pale warm tint (not paint) upon the flesh, a faint indication of red upon the lips, and blue in the eyes; the hair is lightly gilt, and the drapery edged or dotted over with delicate stars in colour.

But we, as architects, in admiring Mr. Gibson's works must not forget the marked difference between sculpture applied to architecture, and sculpture *per se*, or furniture, if we may venture so to call statues which have no distinct destination, but stand upon a pedestal or fill a niche as an ornament to a temple or gallery. In the former the conventional nature of architecture forbids us to raise the idea of living beings entering into its combinations. How disagreeable and absurd would be the impression of living beings perched on a pediment or built into a freize. With statues which do not form a part of the architecture, and being close to the eye, or as it were of ourselves, the case is different. Such statues would be infinitely more interesting if, instead of cold and uniform marble, they present a glorified image of the creature; not so near an imitation as to be a reality, though cold and lifeless, but so much of a suggestion as, speaking to the imagination rather than the senses, shall present an ethereal being,—such an image as one might wish to see in a dream of a beloved person. The next step trenches upon the domain of Madame Tussaud.

With regard to architecture, all the learned research to which I have referred you, though of the highest antiquarian interest, is not the most important subject for our consideration. Let us see whether it teaches us any lessons; and if so, in what respect they affect our requirements and conditions of climate, &c. If we accept the lesson which nature teaches us—as we find the Greeks did—in her geographical distribution of colour, we shall find that the exterior decoration of the ancients affects us very little. As has been before remarked, the brilliant colours which produce so good an effect in a southern climate would be staring and crude under our grey and covered skies. Any colour therefore which we apply to our buildings externally must necessarily be of a very subdued kind,—a combination of half tones; and how can we hope to produce such harmonies as nature will establish for us by a few years of exposure?

There is another very important consideration in comparing the works of the Greeks with our own,—namely, the difference of scale. The Greek temples were the merest toys compared with our great modern buildings. This does not prevent our using colour in some small objects, and in parts close to the eye, as in shop fronts, &c.

But the taste for exterior polychromy has been in a great measure rejected in the best times of northern art; indeed, so far that a large use of varied coloured materials is comparatively exceptional. The combinations of brick and stone, and the occasional introduction in stone buildings of coloured marbles in small quantities, has been canonised by the approbation of centuries, and its good effect cannot be denied.

The beautiful manufacture of Minton's tiles offers us a facility for enrichment which we should not neglect; but where they are used in exterior decoration it should be in small quantities, and so as to be considered as detail, and not as a mass of colour affecting the general aspect and tone of the building. They may indeed be of such colour as to give value to the greys established by nature, while they are themselves sparkling and interesting in detail. Other combinations may be effected by the use of different stones of slightly varied tones; but of this the ingenuity of architects of the present day has furnished too many examples to render it necessary to dwell upon it here.

The inefficiency of paint in our northern climate is sufficiently shown in some of the buildings in the Champs Elysée, Paris, as the Cirque Imperial and several café-restaurants, which, with all their pomp of classical orders, &c., are reduced by their trumpery paintings to the appearance of buildings in a fair. Our climate is not bright enough to give value and brilliancy to paint. If we use colour therefore it must be of such material as, having an intrinsic value, shall supply to the mind that interest which the eye does not feel.

Finally, if the foregoing observations should seem to be directed exclusively to buildings in the country, and which are to harmonise and enter into combination with the objects of nature, it will be found, by carrying out the principle which I have endeavoured to establish, that if strong colour cannot be brought to harmonise with our landscape, sky, &c., "*a plus forte raison*," it will appear crude and inharmonious amid the greys of London.

There is a beautiful method of exterior decoration employed in Italy, and more particularly in Florence, to which perhaps too little attention has been given,—namely, *Sgrafitto*. The mode of execution is this: upon a coating of black plaster a very thin setting of white is passed, and this is scratched through to the black with a point in patterns, figures, or arabesques, &c. There are no doubt difficulties in carrying into execution such a system of decoration in this country. First, the nature of the climate, which is so trying to plaster; then the difficulty, that we feel so much (and in which the French have such an advantage over us), of finding artists, who having the power of free and bold drawing, have not the pretension to "high art" and corresponding pay. But no doubt the first difficulty may be overcome by the various excellent cements which we possess; and this noble institution, upon which government spends so much, ought and will provide for the latter difficulty.

Having thus far considered the external colouring of the ancients, and its bearing upon our own requirements, let us survey briefly the interior decoration, which is of so much more constant application.

The foregoing observations, based as they are upon the analogy with nature, and the combination of architecture with the surrounding scenery, scarcely apply to the conditions of interiors. In an interior, with the horizon bounded by four walls, without the sky as a background to objects—the windows being as it were only pictures, without that most important element of the picturesque, sunlight,—we have to create a Paradise for ourselves,

Digitized by Google

and to supply by conventional beauties the absence of those of nature. In an interior all climates are more nearly the same; and in this country, when we take pains to shut out the outer world, we may imagine any climate we please.

If it be objected that the northern eye, being unaccustomed to brilliant colour in nature, does not require it in his interiors, it may be answered that colour is warmth, and as such is grateful to the northern senses. Besides, our analogy with nature again holds good; for being ourselves coloured in our own persons, and all our objects of use, furniture, &c. being for obvious reasons coloured, surely the receptacles for ourselves and property ought also to be coloured.

Colour in interiors has been a thing accepted in all times and countries, and I am not aware of any school having rejected or put a limit to it. All oriental nations have used colour, and do use it in their interiors. The middle ages, the Revival, and our own times, all agree in this practice. It is therefore unnecessary to bring forward any argument in its support, but only to point to a few examples of the periods more immediately under consideration, with a view not to the advocacy of a new system, but to see whether the practice of the ancients can introduce any improvement into our own system. By-the-bye, there are abundant examples in Etruscan tombs; but as the practice of the best times was of course a great improvement upon this style of art, and as Pompeii and Herculaneum no doubt nearly imitated from those best times, it is hardly worth while to dwell upon those earlier examples.

Of the Greek interior decoration we have no example extant; but we have in history allusions to many examples, and there can be little doubt that the interiors of their temples and monuments were abundantly coloured. We have record of the works of Panænus, brother to Phidias, in the Poecile* at Athens, where he painted the subject of the battle of Marathon. He also painted the temple of Minerva, at Elis. We know of the paintings of Micon and Polygnotus, in the temple of Theseus; the Propylæa, the Pinacothéca, the temple of Rhamnus, the green and red tribunals mentioned by Pausanias, and many other instances might be quoted. It is probable that the subjects formed an important part of the decoration, and occupied a large space. Of the decorative parts we know nothing; it is therefore scarcely worth while to dwell upon antiquarian speculation founded upon the dark passages from ancient authors, which are susceptible of such various interpretations.

The decorations of Herculaneum and Pompeii, of which we have such abundant examples, no doubt follow closely the Greek practice, and they are so full of beautiful motives that we cannot do better than consider a few examples, and try to mark the principles which they contain.

There is much said about polychromy in the present day, but what is new in the application of it seems to be directed chiefly to exteriors, while our interiors are still left to the traditions of the paperhanger. Some few there are who have laboured in this important field of interior colour, and we owe much to Mr. Owen Jones for the steps that he has caused us to take in the right direction. Without his assistance the Crystal Palace would have been but an overgrown greenhouse. Since that we have had other and more complete examples of colour by the same hand, such as St. James's Hall, &c.

One of the most important considerations in interior decoration is perspective,—something to give extension to our generally too small areas. Those who know Pompeii will bear witness to the extension given to the merest sentry-box by the judicious application of colour and ornament. Perspective does not necessarily imply objects represented in perspective upon the walls or ceiling, —what the French call a *trompe l'œil*. A sense of extension may be produced by receding colours thrown back by the juxtaposition of darker or more advancing colours, by the judicious disposition of pictures, looking-glass, &c. Actual perspective representations, such as those in the Church of Gesu, in Rome, and many others familiar to travellers, are no doubt meretricious, and are so directly in opposition to reason that they can hardly be defended. In Pompeii and Herculaneum perspectives are frequently used, but they are so fantastic that they can hardly be accused of an intention to deceive, and though somewhat overstepping the limits of reason, those who have seen them *in situ* will generally acknowledge their charm.

Stern virtue no doubt says, let a wall be a wall, and do not attempt by any means to give false escapes for the eye at the apparent expense of continuity of construction, &c. But the realities of life are sad and dull, and if we can by art feed ourselves with pleasant illusions without deceit, are we the worse for it? Surely the man who, living in an attic, persuades himself that it is a palace, is happier than if he obstinately recognised the neighbouring chimney-pots, and refused to forget the whitewash of his walls. All art is an illusion more or less, and the more the better, so long as it stops short of delusion. But is there no middle course, such as may satisfy both reason and folly, the stoic and the epicurean?

May we not, as before hinted, obtain extension by the use of receding colours, &c.? No doubt in a small room it is impossible to dissimulate the proximity of the wall; but by leading the eye to pictures, which convey in themselves the idea of expanse, a certain freedom is given to the imagination. The heavy picture frames which are so universal are great destroyers of this illusion. In Herculaneum and Pompeii the pictures were generally painted upon the wall; but we know that in the Roman times, and more particularly in the Greek, a large use was made of paintings upon panel; but we must suppose that they were either let into the wall or were made to appear as much as possible a part of it. No doubt there are considerable difficulties in carrying out this practice in our own times, but where practicable there can be little doubt of the advantage of it.

We may also help extension by the use of receding colours. But no colour near the eye will of itself recede or give extension without the help of a foil (in French, *repoussoir*). This is admirably understood in Pompeii. In rooms where light colours are used certain ornamental styles dividing the panels are painted either in darker colours, or, being made out with much detail, engage the eye; and the expanse of flat tint is made secondary, so as to recede from the eye. In a large space at a distance from the eye, as a church or great public hall, certain colours have in themselves receding qualities. The late professor of architecture and architect of St. Paul's, relates that some years ago, when the choir was repainted it was thought advisable to substitute for the blue pilasters, in imitation of lapis lazuli, a more reasonable colour—namely, yellow Sienna marble,—the effect of which was to bring it upon the eye, and materially to shorten the church; and the blue was restored accordingly.

Another leading requisite in interior decoration is variety and multiplicity of parts by which to obtain scale. The Pompeian decoration is full of fantastic architectural features. There is a room in a house (called of Sallust) in Pompeii, which being at the most 12 feet square, has a tiny order not two feet high reigning round the upper part of the room; the panels below being dark, and the spaces between these little columns divided into rustics of various colours. In another case there is a small lararium in the entrance of the same kind of tiny architecture. In the painting such things are constantly repeated.

In a small room where one can recede but little, each wall occupies an angle of 90, 100, or 120 degrees of the visual rays, and should therefore be so subdivided that the 50 or 60 degrees which the eye can embrace should be full of matter of interest, and more or less complete in itself. The small objects occupying that surface would be better in an exterior; but being close to the eye, in comparison only with small objects, their small dimension is forgotten, and they stand upon their merit of delicacy and not of scale and force. It is the imagination which gives them importance, as in a picture a figure 2 inches high conveys the idea of a man. The ceiling of the Sistine Chapel is a remarkable instance of the infinity produced by multiplicity of objects.

In architecture it is a constant practice to place small columns in a room upon the ground, so that half their height is constantly hidden by the people, and their proportion destroyed; but if placed upon a pedestal, and so lessened in magnitude, they may still have scale given to them by contrast. St. Peter's fails in producing upon the imagination the full effect of its vastness, from the want of subordinate architectural features to give scale to the leading ones. Panelling is a means of giving scale and at the same time proportion; but mere subdivision without ornament to give value to the broader surfaces is insufficient.

Lovers of antique decoration must regret the timidity of our decorators in the use of strong colour, and deplore the constant repetition of white and gold drawing-rooms, and indurated fog (called neutral tint) dining-rooms. Nothing but considerations of expense can excuse our whitewashed ceilings, unrelieved by a particle of colour. The light, so much required in our London

* Ποικιλος—Many coloured, adorned, of various colours.

Digitized by Google

climate, would hardly be lessened by the introduction of some ornament. In the last century there was a splendid system of putty ornaments, modelled by hand, but this has disappeared. Why should we not make use of the beautifully painted flowers which are so cheap, in bands, borders, &c. upon ceilings, care being taken that strong colours shall not be so isolated as to come down upon the eye? Much may be done to give interest—height, proportion, and colour—to a room with the materials found in a paperhanger's shop.

Having then laid before you some examples of the practice of the ancients in colouring their exteriors as well as interiors, I would conclude by reminding you that though this is the last and accessory branch of architecture, instead of the first, still the vast interest and delight that it communicates both to monumental and domestic buildings claims our attention as architects, and though we cannot pretend to follow all its practical details, we should be judges of it. The names of B. Peruzzi, Giulio, Romano, &c. &c., have come down to us as combining this with the higher functions of art; but in these times, when the distinction between architects and painters is more distinct, let us hope that painters of talent will give their attention to this subject, and this school no doubt has produced and will produce many.

INSTITUTION OF CIVIL ENGINEERS.

Jan. 11 *and* 18.—Geo. P. Bidder, Esq., Vice-President, in the Chair.
Jan. 25 *and Feb.* 1.—J. Locke, Esq., M.P., President, in the Chair.

The Discussion upon Mr. Scott's Paper, "*Description of a Breakwater at the Port of Blyth, and of certain Improvements in Breakwaters, applicable to Harbours of Refuge*," occupied four evenings.

Before proceeding with the discussion, it was remarked on behalf of the author that an error had been overlooked in the abstract of the Paper. The abstract stated that the breakwaters at Alderney, Portland, and Holyhead had sections which presented nearly, if not all, the advantages of the vertical wall; whereas they were in direct antagonism with the principle of the vertical wall. Now what it had been intended to convey was that the experience at those places had shown that the sea did not disturb rubble at a depth of 15 feet below low water; and that there was a combination of the vertical wall and slope, which was nearly equal to a vertical wall;—as when a nearly perpendicular wall was built upon a rubble mound, as near to the edge of the slope as was consistent with the safety of the foundation; the surface of the mound being 15 feet below low water, and the slope being the natural one of about 1 to 1.

In allusion to a remark, that the pier at Blyth acted like a breakwater, and at the same time as a training wall to conduct the water, it was observed that it was important to ascertain whether the prolongation for a length of 4000 feet or 5000 feet of the natural breakwater, formerly an outlaying ridge of rocks in a direction to intercept the set of the flood tide, had produced any effect on the tidal flow up the river, which had originally extended four or five miles inland. Also whether any observations had been made as to the vertical rise of the tide and the extent of the flow previous to the commencement of the works and since their completion; and whether any comparison had been instituted between the two series of observations, the average of a number of tides being taken; because it was believed that the tidal flow was perceptibly diminished. In the river Wear, prior to the construction of the north pier—that on the south having been previously erected—a wide mouth was exposed to the N.E., which allowed a large quantity of water to pass into the river, causing the tidal flow to reach two miles higher up the river than at the present time. There was likewise a difference of 4 or 5 feet in the present tidal flow at nine miles from the mouth of the river, and quays were in existence in the upper parts of the river which were at present 10 or 12 feet above the high-water mark.

It was stated that wooden piers, nearly similar in construction to one of those described in the Paper, had been adopted in the river Wear upwards of seventy years ago, by Mr. Shoot, the engineer at that period. The carcases were built on the land, in lengths of 30 feet, and launched into the river, loaded with large stones, being floated to their positions and sunk on the sand at about the level of low water. Instead, however, of the interior being filled up with rubble, as suggested in the Paper, the river and outer walls were built up with large blocks of stone, like an ordinary pier, so that when the timber became affected by the worm the wall remained tolerably perfect. The timber was not so much eaten away by the worm on the river side as on the seaward face; and, on taking down some of these old piers, the cills which had been buried in the sand were found to be quite perfect.

It was contended that breakwaters having long flat slopes were more liable to be damaged than those with nearly vertical walls, not perhaps so much by the direct action of the sea as by the recession of the waves when the efflux of the water through the open joints tended to disturb the materials, and when once they were deranged a breach was certain to occur. It was believed that in many instances a redundancy of material had been employed in the construction of breakwaters. It was well known that the violence of the sea did not extend more than 15 feet below low water, and as all that was required was still water inside a breakwater, it was worthy of consideration, whether the sections adopted had not, in many cases, been too broad and too large for effecting that purpose. Then again the materials used as *pierre perdue*, would rarely be found to take an inclination greater than 1 to 1. Thus it would appear that an unnecessarily large expenditure was frequently incurred; whilst if a cheaper and equally durable system was adopted, a greater number of these essential works could be undertaken. With reference to the pier at Dover it was remarked that before the present works were commenced it had been suggested that a simple embankment, similar to a railway work, should have been formed from the materials of the adjacent cliffs, by which means a harbour of refuge would have been obtained at a comparatively trifling cost, and in less time than had already been spent upon the new works. It was thought that as these works already afforded a quay, both for embarking and disembarking passengers, their further extension seaward should be executed in a rough manner, so as merely to prevent the sea from breaking into the harbour. An opinion was also expressed that it would have been more correct to designate the work as the "Wellington Pier," rather than the "Admiralty Pier," as but for the interest which the Great Duke took in the matter the pier would probably never have been executed. The effects of breakwaters upon the adjacent coasts ought to be narrowly watched, or else it might happen that they would cause the destruction of other ports

The piers or jetties of Calais and Boulogne, which had been constructed after Vauban's jetty at Dunkirk, and had been alluded to in the Paper as being similar to that at Blyth, might be cited as examples of the successfully constructed works, well adapted as breakwaters for a flat sandy shore, serving at the same time as conductors and protectors to a channel into and out of the harbour. It was doubted, however, whether this system could be applied to an isolated breakwater in deep water, exposed to the violent action of the waves. It should also be remembered that the western or Old Mole of Genoa, which had been formed of caissons, or chests of timber filled with stone and cement, on which a superstructure was raised to a height of 18 feet, had occupied twenty-six years in advancing 340 yards in length; and that the action of the waves on the face was such as to necessitate large stones, 15 tons in weight, being thrown down in front of it in a depth of water of 60 feet. The destruction of the celebrated cones at Cherbourg might also be mentioned, as affording another illustration of the disadvantages of that system of construction.

It was stated that the Admiralty pier at Dover was formed of a hearting of large blocks of concrete, composed of Portland cement and shingle, and faced with granite. The width of the pier was about 80 feet at the base, and it was founded 45 feet below low-water mark, up to which level it was built by divers. The blocks were continued to a little above half-tide level, and above that point ordinary concrete was filled in between the granite faces. It was intended to have a parapet of Bramley Fall stone on the sea side, but that was not yet constructed. The pier had already been useful for sheltering vessels coming into the old harbour, as well as in forming a landing and embarking place for passengers. It was thought that its extension further seaward would be attended with corresponding advantages, as large vessels would be able to come up to the pier. The estimated cost for a length of 1800 feet, including the parapet, was £650,000.

In regard to a statement in the Paper, that the cost of the works at Portland had been £150 per lineal foot, it was stated

Digitized by Google

that the most expensive part of that work, in the deepest water with the superstructure complete, and including the parapet and a wall 40 feet in width, had not exceeded £120 per foot.

It was considered that sufficient distinction had not been drawn between breakwaters intended for deep water and those designed for shallow seas; and that there was a wide practical difference between the two kinds, which require to be allowed for in their construction. Timber had been shown to be a useful material for making barriers against the sea on the east and on the south coasts of England, on the coast of Holland, at Boulogne, at Calais, and at other places; but none of these were cases of deep water piers, and it was below low water that the great difficulties were encountered. In the construction of a deep water pier at Mill Bay, near Plymouth, where the plan of dropping stone vertically from a timber stage was first put in practice, it was found that the number of pile supports and of timbers must be reduced to a minimum, so as to allow the water to pass through without resistance; the timber work thus becoming a mere accessory to the permanent structure. At the Plymouth breakwater some of the largest stones had been driven out of the top pavement and the inside slope. All experience went to show that in designing works which had to contend with deep sea waves, the greatest possible weight and solidity must be obtained that was practicable with the material at hand.

Allusion was made to a design for a breakwater combined with a landing stage or pier, constructed of iron and wood. A vertical wall of creosoted timber, with a broken or unbroken surface, was supported in its position by wrought-iron piles, with Mitchell's screws as foundations, firmly tied and braced together. It was considered that such a system of structure would greatly facilitate the construction, lessen the time occupied, and reduce the cost.

In a supplementary Paper, "*On the Form and Cost of Breakwaters applicable to Harbours of Refuge*," by J. MURRAY, M. Inst. C.E., it was remarked that a harbour of refuge did not require the enclosed water area to be as tranquil as in a wet dock where vessels loaded and discharged their cargoes alongside of quays. A little undulation in the outer harbour was not objectionable; and the protecting moles or piers would fully answer their purpose if the great force of the waves was broken, and they were thus prevented from doing injury to the vessels at anchor inside.

It appeared to be generally admitted, as to the work under low water, that rubble stone, used as *pierre perdue*, remained stationary until it attained a height of 12 or 15 feet under low water; that the slopes of the deposited mass assumed an angle of 45°, or an inclination of 1 to 1; and that this was the cheapest mode of bringing up the works to that level. In corroboration of this latter statement a comparative estimate was made of the cost of bringing up, by diving-bell work, an upright mole from the bottom, in a depth of 6 fathoms, with a spring-tide rise of 16 feet; and of a simple deposit of rubble stone of the requisite width to receive the superstructure, for which purpose a berm or bench, of 10 feet on each side, was added to the other profile. The estimated cost amounted in the former case to £296 per lineal yard, and in the latter to £37 per lineal yard, both exclusive of staging; while the time required to be bestowed in the construction of the former would be far greater than for the latter. The upright mole would also be considerably augmented in cost if the facing of the walls were of granite, and the interior filled with level courses of concrete blocks, in the manner now being pursued at Dover.

With regard to the superstructure, it was estimated that the cost would vary thus, according to the form adopted:

	Per lineal yard.
1. When constructed on a rubble stone deposit, brought up to 12 ft. under low water, and having a sectional area of 4149 superficial feet	£300
2. Of completing the upright mole, with outer and inner walls, and having an area of 3200 superficial feet ...	£558
3. With rubble-stone blocks and cement	£330
4. With concrete blocks	£303

All these systems were, however, expensive, because skilled labour was employed to a considerable extent in the construction; whereas, for the purpose of a breakwater only, this item should be reduced to a minimum.

In the construction of rubble-stone breakwaters, it was considered that the system pursued by the French engineers of not mixing any small material with the large blocks, as practised at the mole of La Joliette, at Marseilles, and to be adopted at the new mole D'Arène, was the correct principle; for there the large blocks were only used where required, and were not unnecessarily wasted by being sunk in the heart of the work. By this plan it had been found that perfect consolidation was attained with a saving of material. Acting on this principle, it was proposed that for a breakwater in the assumed depth of 6 fathoms the nucleus or core, from the bottom of 22 feet under low water, should be wholly composed of third-class rubble, or from quarry rubbish to blocks of half-a-ton in weight; that this should be coated with second-class rubble, from half-a-ton to 2 tons in weight, which it was considered would remain stationary up to 12 feet under low water; and that first-class rubble, in blocks weighing from 2 to 5 tons, should then be employed up to low water, with a berm or bench on the sea side at a depth of 12 feet under that level. It was further suggested that the upper part should be formed of béton blocks of 20 to 25 tons in weight, being of sufficient gravity to resist the force of the waves, not however as a coating, but as a mass, and terminating at the level of high water; then for 10 or 12 feet above that height two or three courses of heavy blocks, bonded and adjusted by manual labour, should be laid. It had been found at Marseilles that these béton blocks cost 5½*d.* per cubic foot, and at Algiers something more; that the interstices between the blocks amounted to one-third of the cubic contents; and that the blocks arranged themselves at an angle of 45°, or an inclination of 1 to 1. Assuming, however, the price to amount to 8*d.* per cubic foot, and that the section adopted had an inclination of 2 to 1 for the sea side, and 1 to 1 for the inner slope, then the cost per lineal yard would only amount to £200, which contrasted favourably with the estimated cost—£300 per lineal yard—of a mole founded on a rubble deposit; being a difference of £176,000 in a mile of breakwater, or if the comparison was made with an upright wall from the bottom, the saving would amount to £630,000, a sum sufficient to construct an ordinary Harbour of Refuge.

In reference to the calculated cost, £150 per foot, of the Portland breakwater, it was remarked that the basis of the calculation was in the reports laid before Parliament. From the last report it appeared that the total length already executed was 5907 feet, including the entrance, 400 feet wide; and that the cost had amounted to £715,919. In this sum was included the cost of a coal store and jetty, which might be set down at £20,000, and of a length of superstructure of about 1200 feet, irregularly constructed, which, at £35 per foot, would amount to £42,000. These being deducted from the gross cost left an amount of £653,919, which, being divided by the total length of the pier, gave £111 per lineal foot. To this must be added the price of the superstructure, bringing up the sum to £146 per foot, supposing the superstructure to be completed. But as the value of the convict labour was not allowed for in the cost of the work, the author had considered that the amount should be increased by whatever that was worth; taking convict labour as compared with free labour to be as 3 to 8 nearly, being the proportion assigned to it by the engineer of the breakwater, or equivalent to 1*s.* 1½*d.* per day, then the value of the labour of 800 convicts employed during the ten years the work had been in progress, would amount to £24 per foot run, making the total cost £170 per foot, whereas it had only been stated at £150 per foot.

In reply it was stated that the cost of the works, as given in the parliamentary returns, included all the preliminary expenses, amounting to about £80,000 or £90,000, some portion of which had been incurred for special reasons; and that these charges must in fairness be distributed over the whole of the work when it should be finished, as well as over all the contingent works. It was maintained, that in the most expensive portions the Portland breakwater had not cost £120 per foot. The convict labour had not been charged to the cost of the breakwater, and it had yet to be ascertained whether that would affect the result. There were contingencies connected with the employment of such labour which, although only subject to a mere nominal charge, would materially add to the cost in several other respects. The risk was greater, and the works would take a longer time in construction, more especially with a timber stage, and under no other system would it be possible to employ convicts with any chance of a profitable result, or with that degree of regularity and freedom from stoppages during gales which was so essential. At Portland the works had only been delayed from this cause from ten to twenty days during ten years. Then to do the same quantity of work

Digitized by Google

in the same time the "plant" must be greatly increased—say in the proportion of 8 to 3—and it must also be of a special description, suitable to unskilled labour; added to which it would be more liable to damage when used by men without skill and without experience. So that, strange as it might appear, it was much doubted whether any pecuniary saving had hitherto resulted from the employment of convict labour. Now however, by the employment of free labour in particular parts of the work, the rate of progress was being increased, and the scale was being turned in favour of the employment of convict labour.

It was remarked that when a wave reached a vertical wall it was immediately reflected back, producing the converse of itself, and this again gave rise to two reflected secondary waves,—one vertically upward and parallel to the face of the wall, and the other downwards. If the wall was situated in water of a moderate depth, and was founded in or upon sand, mud, or other soft material, a hollow trough would become excavated along the base of the wall by the reflected wave; and unless it was founded deep its base might be undermined. This actually occurred at the Commercial wharf, Kingstown Harbour, some years ago. The seas which washed over the wall, falling forward into the water of the lee side, also produced a wave by their impulse, which penetrated to the bottom, and produced at that side another but smaller trough along the base of the wall. The remedy adopted was to fill the troughs on both sides with angular shingle concrete made with Aberthaw lime.

It was observed that if timber could be rendered permanent it might be advantageously employed in the construction of breakwaters, inasmuch as by its use there would be obtained a continuity of structure, which stonework did not possess unless the materials were of very large size. The structure at Blyth had been exposed to the action of heavy seas from the N.E. for two years without accident. It was thought that an improvement might be effected in carrying out stone breakwaters by means of timber staging, by constructing a permanent stage, carefully put together for the whole length of the intended works, and loading it with rubble stone, so as to form for a time a breakwater in itself. The stage should be sufficiently strong to carry machinery capable of lifting and transporting masses of masonry, constructed on shore, of 25 or 30 tons in weight, and of depositing them on the stone face work continuously, and progressing along its whole length instead of from the end merely.

It was remarked that the estuary of Blyth was similar to that of the Mersey, admitting a large quantity of tidal or back-water. Originally, during N.E. gales, there was no protection to vessels entering the tortuous channel leading to the harbour, and numerous wrecks took place upon the sands to the eastward; while in S.E. gales vessels went upon the ridge of rocks. The breakwater had acted as a guiding-wall to the current, and a straight channel had been dredged out; an additional depth of 2 feet of water had been attained, and vessels were sheltered immediately on entering. So far therefore the structure was successful, and had answered the purposes required.

It was stated that in 1814 the late Mr. Rennie made a report upon the harbour of Blyth, in which he proposed the erection of a stone breakwater, in a similar direction to that now under construction, and also to widen and deepen the entrance channel, jetties being intended to be carried out from the south shore to preserve the channel. The estimated expense of these works was £47,079, or for the pier alone £38,015, being at the rate of £9. 5*s.* per foot; whilst the present pier was stated to have cost £10 per foot; so that no great pecuniary advantage had been gained by the adoption of the system of timber and stone combined. This mode of construction was by no means so novel as it appeared to be considered, for it would be found described in the works of Vauban, Belidor, Sganzin, and other French writers. It had also been carried into effect at Dunkirk, Calais, Boulogne, Dieppe, and other places on the French coast, where there was no means of getting other materials. It was thought that this system could not be applied with propriety to deep water sections; and it was mentioned that several extensive works had already been executed in stone at about £70 per foot. For example, at Kingstown Harbour about 9500 lineal feet of pier were executed at £73 per foot, in a depth of water of from 12 feet to 27 feet at low water spring tides, with a rise of tide of from 8 to 16 feet. Again at Howth, where in 1812 the *pierre perdue* system was first used it was believed in this country, the quay walls and parapet cost only £71 per foot. The Plymouth Breakwater, which was built in a depth of 7 fathoms of low water spring tides, cost £294 per foot, including the masonry, which was expensive; but that was an instance of an isolated breakwater, to which all the materials had to be conveyed a distance of nearly seven miles in sailing vessels, and at a time when the machinery and plant for executing works of such magnitude were not so perfect as at the present day.

It was observed that the cost of the Holyhead breakwater had been about £160 per foot, not £200 per foot as given in the Paper. It was urged that it was impossible to come to a conclusion that any one system of breakwater could be universally adopted; and indeed in no branch of engineering was there one material or one mode of construction proper to be employed under all circumstances. With regard to the particular system under discussion, it was remarked that there was nothing new in the design; for wooden piles, with or without stone thrown behind them, had been generally used where no better material could be afforded. In the United States twenty years ago, with the exception of a single graving dock at Boston, it was believed that there were no walls either of docks, quays, or piers, that were not so constructed. It was thought that loose stones requiring the support of the timber to keep them together, would not stand in such rough seas as the breakwaters at Holyhead, Portland, and other places were exposed to; and if that part of the structure was only intended as a nucleus for a permanent stone masonry structure, from which to build stone walls in water 70 feet in depth, then it was much questioned whether there would be any economy in construction.

In reference to comparisons of the cost of different breakwaters it was remarked, that the cost of a wooden structure in one place could not fairly be contrasted with the outlay incurred in another situation, under totally different circumstances, and on entirely dissimilar works. Great care was required even in contrasting the cost of stone breakwaters in different places; for the rock in one case might be much harder, more difficult to quarry, and more expensive to carry than in another.

It was contended that in the construction of breakwaters the objects for which they were required were not sufficiently kept in view; and that unnecessary labour and expense were incurred in rearing a superstructure which was not at all necessary It frequently happened that the parapet, by opposing a barrier to the waves, caused the water to fall on the platform within, and to disturb and destroy the work.

It was remarked that to execute a structure of the kind described in the Paper, in a depth of water of 60 feet, it would be necessary that the timber frames should be upwards of 80 feet in height. Judging from the difficulty of placing single piles in position in a less depth of water, it was argued that the setting up of each frame with precision in a rapid tideway, which generally prevailed round the head of a breakwater in progress, would be a matter of considerable difficulty. It was doubted whether the manœuvring of such large masses of buoyant material could be accomplished with advantage, even where it was practicable. It was thought that where there was only a small base of rubble it was preferable to float the material to the spot, as had been done at Alderney, rather than to adopt the method of depositing it from a stage. For executing the superstructure it had been proposed to introduce intermediate frames resting on rubble. Supposing the rubble to sink, which it undoubtedly would do to some extent, then either the intermediate frames would receive no support from the substratum, and they must be held in suspension by the main frames; or, on the other hand, if they were sustained by the rubble the continuity and rigid attachment of the timber framing could no longer exist. In either case a portion of the strength which seemed to be anticipated would be lost. Hence it was believed that before the superstructure could be proceeded with the main frames would have to be cut away, so as to present an equally yielding base for the superstructure to rest upon. The relative advantages of timber and stone for these works were then commented upon; and it was thought that although the first cost might be reduced by using the former material, yet it would scarcely ever be adopted where heavy seas had to be resisted. Again, if the dimensions of the timber were increased so as to withstand heavy seas, the system would be much more expensive than had been stated. It should also be remembered that although timber and rubble stone might be cheaper per cubic foot than stone alone, yet the advantages were not so great when the comparison was made by weight.

It was remarked that the subject of the Harbours of Refuge,

Digitized by Google

independently of the mechanical and engineering part of the question, was of vast importance in a national point of view, whether as relating to the necessary protection of the commercial marine, or as connected with the naval defences of the kingdom. In order to rendering clear the points to be touched upon, it had been necessary to examine those formidable and not very lively documents, the Parliamentary Blue Books, and they confirmed the opinion, that all these great works were being executed without any efficient responsible supervision or control; and that not only the public and the representatives of the nation, but also the government itself, had been utterly in the dark as to proceedings relative to them. The time had now arrived when these matters should be brought before the bar of public opinion, and as it was almost impossible to induce a dispassionate examination of the subject elsewhere, the Institution of Civil Engineers appeared to be the most fitting arena for the discussion of the question.

The mechanical portion of the subject was first briefly alluded to by reference to the reports of the several committees on Harbours of Refuge, commencing with that of 1845; which, though not absolutely the first, was that which first actually examined into the most important points. On the question of the recommendation of upright or of sloping walls, in spite of the aid given by scientific and practical men, the committee differed so widely that a supplementary report was published, exhibiting the opinions of the dissidents from the first Blue Book. Now it was submitted that this difference of opinion had chiefly arisen from not having arrived at a clear understanding of the terms used, and of the basis of the various arguments employed.

It would not be necessary now to re-open the question of the theory of the waves of oscillation and of translation. It was admitted that in the case of a pure wave of oscillation, the upright wall would receive the least amount of actual impact; and that the wave would be reflected from the surface at a corresponding angle to that at which it impinged; but when that wave became a wave of translation, the upright wall was the worst form that could be adopted, as it would be struck with the utmost accumulated force of the sea.

In applying these and other views to practical cases it must be assumed that the facts were derived from the Blue Book, which however, like the Queen's Speeches, appeared to contain everything except the specific information sought from them.

Now, in looking at the plans of the works as given in these parliamentary documents, the section of the breakwater at Alderney appeared to be of the worst possible form. There was a slope or berm below low water, then a slope of 1 in 7, and then a perpendicular wall; it was contended that upon this combination of forms the effect of the waves would be most pernicious.

When there was to be a vertical wall, the slope should be so placed as to exhaust the force of the waves before they reached the superposed upright wall: this was judicious, and it was evidence of the correctness of the doctrine, that the form of section of sea walls should depend upon local circumstances, and should be fixed by the practical judgment of the engineer. At Dover a slope would not be practicable, as there were only soft materials at command, whereas at Holyhead and at Portland there was abundance of hard material, and it was evident that in these latter positions slopes of *pierre perdue* were the proper kind of works to be executed, as they were less expensive, and required the exercise of less engineering and mechanical skill than upright walls. These latter were doubtless expensive works, and it was contended that if they could not be constructed at a less expense than the pier at Dover, which was said to be costing £415 per lineal foot, such structures must be abandoned. At the present rate of progress the projected Harbour of Refuge at Dover would scarcely be completed in less than one hundred years, and at an outlay of £5,000,000. But the actual cost would not be represented by that amount, as if the interest of that sum was spread over the hundred years consumed in the progress of the work, it would with the principal amount to £40,000,000. Supposing then that our ancestors had commenced this harbour at Dover in 1759, what would have been its utility as a work of military defence during the past continental struggles, and would not £40,000,000 be much more usefully employed in reduction of the National Debt than in a work of doubtful utility either for the commercial marine or for the navy? If such works must occupy even fifty years, they had better not be commenced at all, as by the time they were completed the perils they were intended to guard against would have passed away. The great object then must be to devise some other and simpler system of construction for works of this kind; and it was a question whether some such plan of breakwater as those of which drawings and models were exhibited by Mr. Hays, Mr. Brunlees, or Mr. Johnson, could not be adopted with advantage; those systems appeared to consist of iron piles, founded upon Mitchell's screws, and bearing a sheathing of close or open timbers, against which the waves would impinge. The system appeared to possess certain merits, and, under peculiar circumstances and in properly selected localities, could probably be made available, as a considerable length could be put down in a short space of time; and in the hands of experienced engineers such a mode of construction might be rendered available for reducing the present enormous cost of piers and works intended for the protection of shipping. With the diving-bell and helmet, and the Nautilus and other available means of securing the putting down of any kind of iron piles, it would appear easy, if these works were thrown open to the engineering skill of the country, to find the means of executing them with much greater rapidity and at considerably less cost than at present.

Reverting to the Blue Books, they would be found to reveal many things which were not generally even surmised. To the report of 1845 there was appended the signature of Mr. James Walker, past president of the Institution. That report stated, that the cost of breakwaters, whether constructed of *pierre perdue* or built as upright walls, would be nearly identical. Now, as a commentary on that statement, it must be observed, as far as a Blue Book fact could be received, that the pier at Dover had cost £415 per foot, and that at Portland less than half that sum. It was further stated that the works at Dover were to cost £2,500,000; those at Seaford, £1,250,000; at Portland, £500,000; and at Harwich, £60,000. Of these four works so recommended, three had been commenced, and two of them had been entrusted to Mr. James Walker, himself one of the commissioners.

The facts respecting Dover appeared to be, that the first contract was for 800 feet extending from the shore, at a cost of £234,000, or £290 per lineal foot; and the renewed contract in 1854 was for 1000 feet, at £415,000, or £415 per lineal foot, and to be completed in 1864. It must be assumed that Parliament sanctioned that work, ordered it to be proceeded with, and voted the money, on the report of the commissioners; yet in 1858, on some of the members of a committee of the House expressing surprise at the slow progress of the work, and asking Mr. Walker this question—"Was it known, at the time it was decided to make the works at Dover, that it would take half a century to make them?"—he replied, "I do not suppose it was. I do not think any idea was formed at the time as to the cost, or the mode in which it should be done." Hence it might be assumed that works were authorised, and the money of the country was voted away by the government, without any idea being given of the time of construction or of the cost of such works, nor even of the mode of their execution. Now mark the result at Dover: about £400,000 had already been expended, and yet it was at times nearly impracticable to effect the landing at low water of the passengers from the small steamers arriving from Calais, until the outward-bound steamer had left. This inadequate result, after such expenditure, was not creditable to the administrative skill of the government of the country.

At Portland the original approximate estimate was £500,000, which for the rough stone alone was extended to £558,000. It was however discovered subsequently that the mass of stone must be wider and deeper, and therefore the cost was increased to £932,000; and it was stated that this addition was caused by an error of 7 ft. 6 in. in the depths, which had been determined by soundings taken by one of Her Majesty's surveying ships, which had been specially deputed to make a chart of Portland Bay. Why an error of this kind—involving an expense of £95,000—had been passed over without any public notice, remained to be explained by the department of the government which was responsible for it.

Considerable discrepancy of opinion appeared to exist with respect to the value of convict labour, which it should be remarked was more extensively employed at Portland than at any other place. Nearly all the stone used in the works was quarried by convicts; it was then taken by the contractor, hauled to the top of the self-acting inclined planes (supplied by the government), and was tipped into the sea vertically from a stage erected by the contractor, who had merely to dispose of the material supplied to him by the convicts. It would at the first view have appeared easy to estimate the value of the material, and to charge it against

Digitized by Google

the works executed. This however did not appear to be done. It was averred in the Blue Books relating to the management of prisons, that the criminal establishment at Portland was self supporting, inasmuch as the labour of the convicts was profitably employed in the harbour works. On the other hand it was stated, in the Blue Book relative to the harbours of refuge, that this labour did "not save one shilling in the work." Now between these two statements there was a manifest discrepancy, which should be explained, as it was evident that the £30,000 to £50,000 annually expended on the convict establishment at Portland should produce something. The prison authorities said that the establishment cost the country next to nothing, whilst the Admiralty contended that the harbour works upon which the convicts were employed were as costly as if free labour had been employed. Now it appeared that both were a little wrong; the Inspector of Prisons might perhaps attach more value to the convict labour than properly belonged to it,—but it was absurd to say that the quarried stone, delivered on the tramway ready for deposit by the contractor, was valueless. Indeed it might be safely contended that the £930,000, representing the ultimate cost of the Portland works, would eventually be increased to £1,500,000 when the convict labour and the interest of the money was taken into calculation.

It apppeared from the Blue Books that the cost of the stone, receiving it ready quarried, and lowering it by inclined planes erected at the cost of the government, and tipping it into the sea, amounted to between three and four shillings per ton. Now this price appeared excessive as compared to the cost of similar works in other positions, and it induced the conviction that if the whole work had been opened to free and open competition, it would have been done at a less cost to the country.

Alluding to the design of the Portland breakwater it was observed that an opening of between 300 feet and 400 feet wide had been left at a certain distance from the shore, in such a position as to admit of heavy seas rolling in, to the detriment of the anchorage ground in the harbour, whilst from its position it was manifestly useless for sailing vessels either entering or leaving, and could only afford an advantage of three or four minutes even to steam vessels. Besides this opening required elaborately constructed pier-heads, which as specimens of work reflected the highest credit on all who were connected with the breakwater; but they had cost nearly £100,000, which was a heavy cost for a doubtful advantage. Moreover in any future repairs of the breakwater this opening would be found to be a source of much inconvenience as well as of extra cost.

The Harbour of Refuge of Alderney, which was estimated to cost £1,300,000, had been placed in a situation where it was nearly valueless, as all shipping carefully avoided that part of the channel.

The works of St. Katherine's Bay, Guernsey, which were shown by the Blue Books to have cost £300,000, were even if possible still less useful, as if a vessel would avoid Alderney it would certainly not go near to Guernsey. The works were now stopped, and after all the expenditure there was scarcely shelter for a few oyster boats.

The parliamentary returns were nearly silent with respect to Holyhead. It appeared, however, that the original estimate had been £600,000; but the expenditure up to the present time was £930,000. The utility of this work was undoubted; it was in the right place, and the government had at last wisely placed it under excellent and judicious management. There was, however, an unfortunate error in the original design of the work; the piers having been built concave in plan instead of convex towards the sea; thus making an angle in the construction which was very prejudicial; and it was evident that if the plan had been originally well considered nearly 200 acres more of harbour space would have been obtained at the same cost. In fine, it appeared that but little hopes could be entertained of more rational proceeding on the part of government so long as commissions were constituted as at present. The few members of acknowledged independence were swamped by other members determined by foregone conclusions, and the schemes proposed by certain parties, were by some "hocus pocus" generally recommended. It was evident that no person should be placed upon such commissions who was pledged to any system whatever; nor should the execution of any work be confined to any member of a commission by whom that work had been recommended. There were many modes of carrying out these views, and if a better and more equitable method was adopted the best professional ability and the greatest executive skill would be secured to the manifest advantage of the country.

This subject was one which well merited the attention of some independent member of the House of Commons, who might do good service to the country by pertinaciously attacking and exposing the present objectionable system of executing all government works.

It was explained that the superstructure at Portland, which was only commenced on the pier connected with the shore, was founded at the level of low water. It would have been better if the work had been commenced at 12 feet or 15 feet below low water.

As to open competition for government works, the works at Portland had been submitted to six of the most eminent contractors in the kingdom.

What had been stated in the evidence in the Blue Books was, that it was difficult to determine whether any absolute money-saving resulted from the employment of convicts upon such works as those at Portland. Now, however, from a combination of circumstances there was reason to believe that convict labour was rendered commercially advantageous. There were, however, advantages attending the useful employment of the convicts which could not be estimated commercially;—the industrial and moral training to which they were subjected during their period of forced labour tended to their reformation, and towards restoring them to society as useful men instead of outcasts. Thus if the cost per lineal foot of the Portland breakwater should be actually as great as that of another breakwater executed by free labour, there was still the advantage of the reformatory instruction and training given to the convicts.

It should be observed that in the construction of a breakwater in an exposed situation the cost would, in a great degree, depend upon the time the work was in execution, because in heavy weather the sea risk was greatly increased, when the quantity of stone tipped was limited by the want of facilities; whereas, with the extensive means afforded by a long staging, such as had been created at Portland, the quantity of material deposited could be almost unlimited, and it could be done so rapidly as to diminish the sea risk.

The opening in the breakwater which had been alluded to was decided upon by the commission on Harbours of Refuge of 1845. The object was evidently to afford facilities to ships leaving the harbour during northerly winds; and hitherto no ill effect had been felt in the harbour from the admission of any heavy seas by that opening.

With respect to the plan of the pier at Holyhead, it was explained that when the harbour was first projected a strong and successful pressure was brought to bear, by the Liverpool interest, against the formation of a port in that locality; and small area only was therefore ordered to be enclosed. It was now found that this area was too small, and further works were imperatively demanded, which could only be joined on to the old pier, by an extension in the direction that had been shown; and if there was an apparent error in the plan it must not be attributed to the late Mr. Rendel, by whom the works were designed.

It was explained that this had not been intended; but what was the use of the controlling nautical authorities, who were so active upon all commissions, if they permitted such grievous errors of design simply because an outcry was raised by interested parties from another locality? These nautical authorities were not always so impressionable by just representations; and if they could not independently determine the requisite area of a new harbour, it might with propriety be asked of what utility were they as members of commissions?

As to the employment of convict labour at Portland the discrepancy between the statements of the two departments of government had not been explained, and an annual sum of nearly £50,000 disappeared in some unaccountable way without any satisfactory reasons being rendered. Neither were the beneficial effects of the moral and industrial training admitted, as the testimony of the warders of the convict establishment showed that real reformation was very rarely induced in any of the prisoners.

It was explained, with regard to the works at Alderney, that the section of the pier was exactly that which was so strongly advocated; the vertical wall was founded at 12 feet below low water of spring tides.

As to Jersey, that place was at one time considered to be the most important of all the harbours in the Channel Islands; but some change of opinion appeared to have occurred, as the government had only authorised the construction of one arm of the

Digitized by Google

breakwater, and had neglected the other. The harbour was thus in such an unfinished and exposed condition that no vessel would go into it.

As to Dover the expenditure was given in lump sums in all the Blue Books, and the amounts now quoted as the cost per lineal foot were not correct, inasmuch as the gross sum embraced the cost of the landing jetties and other things which should not be included in making a comparative estimate of that work, and contrasting it with others.

Before the plan of the Dover works was decided upon the evidence of several eminent civil engineers was taken; the direction was then confided to Mr. Walker; and application for tenders for the execution of the work was made to six or more of the most eminent contractors, to one of whom it was let for a gross sum.

The breakwater at Dover could scarcely be contrasted with any other work, as at present it was essentially only a landing pier; although it would eventually form part of a harbour of refuge. The mode of construction was different to other works, as, owing to the absence of hard material in the neighbourhood, it had been necessary to resort to the use of concrete blocks formed of cement and shingle. The result had been perfectly successful, as not a crack appeared in the walls, although the foundation was not good. The time actually occupied in executing the present length of pier was not any criterion of what could be done; at present a certain annual amount was ordered to be expended, for which so much work was executed, but at least double that quantity could be executed if the necessary funds were voted for the purpose.

It was mentioned that the béton system had been first introduced by M. Poirel in 1838, at Algiers. It had been tried there on a large scale, and had since been adopted at the new port of La Jolliette, at Marseilles. Where no better materials could be got, it was thought worthy of the consideration of engineers; but as regarded cost, it was believed the price of béton would be found to vary from ten to twenty-two francs and upwards per cubic metre, according to the quality. This was nearly four times as costly as some of the inexpensive stone breakwaters already alluded to, where the material was at hand, and was readily obtainable—at a cost in the work of from three shillings to four shillings per cubic yard. In these cases the great expense of staging was saved by forming the breakwater like a railway embankment, and using the embankment itself as the stage from which to "tip" the material. Then as the work advanced the sea caused the materials to assume that inclination at which they would stand. This was spoken of as the simplest, the cheapest, and the best mode of forming a breakwater run out from the shore.

In reference to the remarks which had been made as to the harbour at Jersey, it was stated that by the original design it was to have been formed on the opposite side of the island, by excavating or indenting the land for the purpose, as had been done at Cherbourg. If that plan had been carried out, a useful work would have been obtained at less cost than the present harbour.

With regard to a report that it was probable parliament would be recommended to authorise the expenditure of about three millions sterling in the construction of harbours of refuge, it was remarked that that amount distributed over the coasts of the United Kingdom was so limited, that the cheapest plan of construction, combined with efficiency, must necessarily be selected. It was on this ground that a framework of carpentry filled in with rubble stone had been mainly advocated; and it had been estimated that such a structure could be executed in deep water for 70*l.* or 80*l.* per foot. But, on the other hand, it was thought a bold assertion to say that this system was a good substitute for the stonework of the old school, for in all probability the first rough sea it had to encounter would destroy it; and as far as economy was concerned, many stone breakwaters had been constructed at even less cost, where facility for obtaining materials had formed an element, as it always should do, in the determination of the site for the breakwater.

In allusion to a remark as to the probable disintegration of the béton blocks, it was stated that experiments instituted in consequence of a failure at St. Malo had proved that all rich limes mixed with sand and pozzuolano failed in salt water, though they succeeded in fresh water. Therefore, since 1852, the French engineers had used hydraulic limes exclusively in all sea works, and no failure had taken place. With reference to a statement that the works at Marseilles were not so exposed as similar works in many other places, and that therefore no fair conclusion could be arrived at as to the general applicability of béton blocks, it was mentioned that a large fort at Rochfort, in the Bay of Biscay, had been founded in 1802-3, on such blocks, 33 tons in weight, that they had remained perfectly stationary, and did not now exhibit any signs of disintegration. The breakwater at Cherbourg might be cited as an illustration of rapidity of execution in an exposed bay. The first cone was sunk in 1751, and the last in 1788—the distance between the two being 2 miles 3 furlongs. In the first seven years the whole of that length was brought up to within 4 feet of low-water mark. The cost, including the pay of the seamen and soldiers employed, was about 300*l.* per lineal yard. The additions to the superstructure, made since 1832, brought up the total cost to 433*l.* per lineal yard, and including the central battery to 658*l.* per lineal yard. This formed a striking contrast to the cost of the works at Dover, which it was found from the parliamentary returns had amounted at first to 800*l.* per lineal yard, and in a depth of 7½ fathoms to as much as 1245*l.* per lineal yard.

It was remarked that it would be interesting to ascertain the difference between the first cost of that portion of the pier at Blyth which had been built of stone alone, and that which had been constructed of timber and stone combined. In sea works the slopes should be uniform, so as not to expose a number of angles to the wash of the sea. This principle had been kept in view in the sea embankments in Morecambe Bay, where the walls throughout were at a uniform angle with the foreshore, and at such a slope, that the receding wave instead of falling directly upon the toe of the wall, as would have been the case if the wall had been vertical, was modified to such an extent that the toe was easily protected and suffered no injury.

Allusion was made to a pier which had recently been sent out to the River Plate. The piles were formed of four angle irons bolted together and fitted with Mitchell's screws. The girders were 18 feet in length, for convenience of shipping. When the materials arrived they had only to be fitted and bolted together, and the structure was complete.

A description was given of a breakwater constructed for the South Australian Government at Port Elliott, Encounter Bay, about five years back. The work was carried out from the base of a headland of granite, blocks of stone from 2 to 7 tons in weight being quarried and tipped down. As the work advanced, lines of rails were laid down on the top of the embankment, and the whole was finished at once to its full height. The blocks took their own natural slope, which was found to be about 2 horizontal to 1 vertical. About 100 lineal yards were completed in rather less than two years. The top of the breakwater was 21 feet wide, and 5 feet above high-water mark. It was carried into a depth of 2 fathoms at low water, with a rise of tide of 5 feet. This work had stood perfectly well, though exposed to the full strength of the sea from the open Southern Ocean, and to a perpendicular lift of sea of 14 or 15 feet. The principle and construction of an iron breakwater, semicircular in plan, and 240 feet in length, designed by Mr. Hays, to protect the head of a landing pier at Holdfast Bay, near Adelaide, were then described. It was observed that this form of structure was equally applicable as a breakwater for harbours of refuge. The portion designed to resist the sea extended from a height of 6 feet above high water to 12 feet below low water. It consisted of a series of parallel plates of wrought-iron, inclined at an angle towards the waves, and at distances of about 1 foot apart. These plates were firmly bolted together, and were supported upon wrought-iron (Mitchell's) screw piles. The angle of the plates was intended to be such, as to be as nearly as possible in the plane of the motion of the water, by which the structure itself would be almost entirely relieved of the shock of the sea. It was thought that such a breakwater would be cheap in construction, rapid in execution, and would permit the free flow of the tidal currents, so as to avoid the risk of setting or stopping the travel of shingle.

It was remarked that the power of the timber breakwater, described in the paper, to resist the force of a deep sea wave, depended upon two points: the absolute stability of the work, and the force of the wave which it had to withstand. A consideration of the mechanism of waves, on which depended the correctness of the form of breakwater, seemed to show that the sections for deep water had less force to resist than those for shallow water; and the opinion was advanced, that the force of the waves at

Digitized by Google

Holyhead was created by the breakwater itself, and that it would not be so much felt in deep water. The case of a solitary wave of translation, travelling along a channel of uniform section throughout, was first considered. It was shown that the facility of the propagation of the pressure increased as the square root of the depth,—that the velocity of the forward motion of the particles under the crest of the wave was to the velocity of the wave as the height of the wave was to the whole depth, measured from the crest,—and that the momenta of the several columns as regarded forward motion, was the same as if the volume of the wave was moving forwards with the velocity of the wave. It was manifest, that since the momentum in all cases was the same, and since destructive energy varied as the mass in motion multiplied by the square of the velocity, that the destructive energy of a large volume was less than that of a small one. When a wave met a sloping bottom the velocity was retarded, and the wave rose and became shorter; consequently the number of particles in motion was less, and the distance moved through and their velocity were greater. This increase in height and of motion continued until a point was attained when the motion of the particles was equal to the velocity of the wave. It then curled over and broke, when the maximum of the destructive force was attained. When there was an artificial foreshore in front of a breakwater it must cause the wave to break, and the force which was innocuous became extremely powerful. The waves of the sea were however oscillating waves, consisting of a succession of waves instead of a solitary one. If the force of a wave of translation in deep water was small compared with what it might become if converted by a sloping foreshore into a breaker, it followed that the force of an oscillating wave must be still less. It was found that a wave rose considerably above its own height against a vertical face; the total height to which it rose being the measure of the pressure exerted upon the wall. In support of the truth of these principles the breakwater at Alderney was referred to. The first wall consisted of large stones as they came from the quarry, built with a batter of 9 inches to a foot, and founded about low-water mark on a foreshore sloping downwards from that point. A length of 200 feet of that wall having been swept away, it became necessary to reconsider the design. The new work, of which a length of from 600 to 700 feet had been constructed prior to the storm of November 1850, was founded 12 feet below low water. The foreshore was carried down from that point to a distance of upwards of 100 feet, at a slope of 7 to 1; and having then reached 15 feet below low water, it dropped at the natural slope of 1 to 1. The rise of the tide was 17 feet, and the wall was 25 feet above high water. In the great storm the waves were observed to curl over above the parapet, and to break upon the wall with considerable force. The stone was hard quartz grit, that in the foreshore being sharp and angular, and so great was the action of the sea, that the stones became rounded and smooth, and the face of the wall was polished. From these remarks, it was concluded that the perpendicular wall from the bottom was the true form for breakwaters, and that the forms proposed in the paper were based upon correct principles.

In reply to the remarks of the different speakers, it was observed that the proposed system of construction differed materially from the wooden piers described as having been erected in the river Wear seventy years ago. The carcases, in the latter case, were said to be loaded with large stones, whereas the Blyth section was not a box, but a framework entirely open at the ends and bottom, and partly at the sides; it had, therefore, no power to float stones. It was also submitted, that in deep water or even in shallow water, with an irregular rocky bottom, it would be impossible to carry out the system of carcases. All however that was claimed in the proposed system, was an improvement in the mode of construction, although it was believed that a similar work had never been described nor constructed before; certainly it was quite different from the caissons carried out at Genoa. With regard to the cones at Cherbourg being identical, it was impossible to imagine anything more dissimilar, for the cones were entirely isolated at intervals of several hundred feet; whereas one leading advantage of the proposed system was the continuity of face, whereby every part of the work received support from the neighbouring portions. No doubt wooden piles, with or without stone thrown behind them, had been used in this country and elsewhere, but that system was only applicable to moderate depths. But piles were not intended to be used, for they were inapplicable in a hard rocky bottom and for great depths. As to the assumed difficulty of erecting the frames, it was stated that when set up on end they were not like a mass of timber floating loosely, as they rested on the bottom by their own weight and had no floating power, a great part of the mass being above the water. Attention was then directed to the difference between the action of the sea in shallow and in deep water. In the former the waves necessarily broke on the work, whereas in deep water, and with nearly vertical faces, the waves did not break. If therefore any given work would resist the impact of the waves in shallow water, it would be much more likely to do so in deep water. At Blyth a comparatively fragile work had withstood the full force of the waves of the German Ocean; and to show the power of the sea there, it had been known to move a stone 9 tons in weight, and to lift a stone 3½ tons in weight up a perpendicular face 4 feet high.

As to the objection that the stability of the intermediate frames might be affected by the settlement of the rubble bank, it was remarked that the bank was deposited and allowed to settle before the frames were erected. When the frames were placed, the stonework was only carried up to the under side of the cross ties; and even should any settlement take place afterwards, the lower tie being a chain was not affected by it, and it could not affect the uprights. When this hearting had become consolidated, the upper part of the work was filled with stone, and dry walls were built along each cross tie, so as to prevent any settlement of the superincumbent stone from injuring them. With reference to the proposed plan of breakwaters with upright walls to be constructed of large masses of concrete, it was remarked that the parapet had been altogether omitted. The parapet might be dispensed with in such a case as Plymouth, where the sea was broken by the long sloping foreshore, and therefore entered the harbour as broken water; but with such a section as that described, the mass of the wave would go right over the supposed breakwater into the harbour. In regard to the cost of the Portland breakwater, if the preliminary expense of 80,000*l.* or 90,000*l.* were distributed over the whole intended work, being a length of 8000 feet, instead of over the 5907 feet already completed, that would only reduce the cost given in the paper by 4*l.* per foot run. As to the employment of convicts involving a larger plant, it was observed that the only part of the plant affected would be that used in the quarries, being but a small part of the whole, and the cost of which would not amount to above a few pounds per foot of the work.

The proposed system had been explained generally, and the principles upon which it was based stated, without those details being entered into which might require to be modified to suit particular localities. It appeared to have been overlooked that the timber system had been advocated as the backbone of a permanent stone structure. Viewed in this light, a comparison was instituted between two breakwaters, identical in form, in external dimensions, in material, and in prices; the one constructed under the most improved of the existing systems, and the other under the new system. It was found, that for a length of 2000 yards in a depth of 52 feet of water, the former would cost 718,934*l.*, and occupy twenty-one years in construction: whilst the latter would only cost 538,622*l.*, supposing the creosoted timber to last twenty years, or 600,585*l.* if the timber only endured ten years, and would afford the same amount and kind of shelter in five years. The progress of the ordinary stone breakwaters was limited by the time required for the erection of the superstructure, as the rubble bank could always be formed with sufficient rapidity. Under the new system a harbour would be enclosed in five years, instead of in twenty or twenty-one years on the old system; and the timber breakwater would afford great facilities for the construction of the faces, as there would be no current to contend with, and the work might be proceeded with at many different points at the same time, instead of being confined to one spot.

JOSEPH LOCKE, Esq., M.P., President, in the chair.

Feb. 8.—The Paper read was "*On the Performance of the Screw Steamship Sahel, fitted with Du Trembley's Combined Vapour Engine; and of the sister-ship Oasis, with Steam Engines worked Expansively, and provided with Partial Surface Condensation.*" By JAMES W. JAMESON.

Before proceeding with the main object of the Paper, which was to record the results obtained during twelve voyages of each

Digitized by Google

ship, made for the purpose of testing the comparative value of the two systems, the author gave a brief description of the Combined Vapour Engine. The principle of this engine was based upon the fact that the condensation of a liquid, such as water boiling at a high temperature, might be effected by surrounding an external condenser with a liquid such as ether boiling at a low temperature. Thus the condensation of the vapour of the one might be made the means of generating the vapour of the other; and a useful effect might be obtained from the heat given out in condensation. The engine up to a certain point resembles an ordinary steam engine with surface condensation, except that the surface of the vessel called the vapouriser, which was also the condenser of the steam, was surrounded by ether instead of water. The heat evolved by the condensing steam generated ether vapour. This vapour accumulated in the upper part of the vapouriser, and was conveyed from thence to a cylinder fitted with a piston, &c. precisely like an ordinary steam cylinder, in which the ether vapour exerted its force. From this it was conveyed to another external condenser, where it was condensed by means of cold water, and was then returned to an air-vessel, in which any air that might have entered was separated from the ether. From this vessel it again passed to the vapouriser, in which it condensed fresh volumes of steam, and was once more turned into vapour. In a steam-boat with a pair of engines, one would be worked with steam in the ordinary way, and the other with the vapour of ether. The vapourisers and condensers were composed of a number of elliptical copper tubes fixed into brass tube-plates. The tubes were generally 5 feet in length, $\frac{1}{25}$th of an inch in thickness, and the bore was a flat ellipse, measuring 1 inch by $\frac{1}{4}$ of an inch. These tubes M. Du Trembley preferred to have drawn solid, without any brazed joint or other seam. The tubes, after having had their ends tinned, were placed in the mould for the tube plate, and the molten metal was then run round them, by which a very tight joint was made between the ends of the tubes and the plates. Groups of these tubes, properly fastened together, were placed vertically in a cast-iron case, in which the exhaust steam was introduced, so as to surround the outside of the tubes. The liquid ether to be boiled off and to condense the steam was placed within the tubes, arrangements being made above the top tube-plate to collect the vapour, and prevent its mixing with the steam that surrounded the exterior of the tubes. The condenser was nearly similar to the vapouriser, except that the tubes were placed horizontally, and were curved slightly upwards in the middle, so that the ether obtained from the condensation of the vapour might readily escape from the tubes.

The author then succinctly alluded to the experiments made by Mr. Rennie, on board the ship Du Trembley, in the year 1853, which led to the application of the system in two new ships, the France and the Brésil, of 300 nominal horse power, belonging to the Compagnie de Navigation Mixte, of the port of Marseilles. These vessels performed an uninterrupted service for upwards of eighteen months between Marseilles and Kamiesh, during the Crimean war; and were so favourably reported upon by M. Meissonier, Ingénieur des Mines, and M. Gouin, Ingénieur des Ponts et Chaussées, that it was determined to apply the system to seven new ships. Ultimately however, in consequence of the burning of the ship France in the port of Bahia, and owing to the failure of the Brazilian line of steamers, after three voyages, the system was only applied to three ships on the African line. These vessels were the Sahel, Zouave, and Kabyle, of 825 tons displacement, and 180 nominal horse-power. About the same time the Compagnie Franco-Americaine having made some incomplete and unsuccessful trials of ether engines, in the ships Jacquard and Francois Arago, gave up the system. These two engines were then arranged to work by steam alone, the tubular apparatus being made use of for surface condensers. It was said that by this arrangement such favourable results were obtained, as to compensate for the suppression of the ether. All these circumstances combined, induced the two companies to engage the services of M. Moreau to conduct a series of experiments to determine the relative economy of the two systems. In his report he endeavoured to prove, that although in the combined engine a consumption of 880 lbs. of ordinary Cardiff coal and 2·16 pints of ether per hour had produced 439·6 indicated horse-power, or 2 lbs. per I.H.P. per hour, yet a result almost equal to this might be obtained from engines of the same dimensions by employing steam of the same pressure as in the combined engines, and by using a diminished introduction, a greater expansion, and surface condensers. Subsequent experiments corroborated the results arrived at by M. Moreau, as to the consumption of fuel; but in a reply to that report, the accuracy of his reasoning and calculations was disputed. The directors of the Compagnie de Navigation Mixte, however, determined that the plan proposed by M. Moreau should be carried out in the ships Oasis and Marabout, also belonging to the African line; and this had enabled the present comparison to be made.

The engines and boilers of the two ships, Sahel and Oasis, as well as the hulls, were identical, except that the boilers of the latter had about one-third more heating surface. The voyages, twelve in number, were perfectly similar in all respects, and occupied eight months, during which time about 14,000 miles were run by each ship. During the experiments the mean indicated power was found to be 405 H.P. in the Sahel, and 273 H.P. in the Oasis and the Marabout. In the former the total consumption of coal taken on board was 3·1 lb. per I.H.P. per hour, and in the latter 7·12 lb. per I.H.P. per hour—that of the Oasis being 7·5 lb., and of the Marabout 6·75 lb. These rates of consumption were obtained by dividing the total amount of coal used on board for all purposes by the actual number of hours under way. They, therefore, include the quantity consumed in getting up the steam, as well as that used for cooking, &c. The rate of consumption was also affected by the inferior quality of the fuel frequently used, by the considerable waste, and by the great number of hours under steam compared to the hours under way. These rates, though high, did not exceed the usual rates for ships in the port of Marseilles, fitted with direct acting engines of the same power. The most economical results obtained in any of that class were those of the ship Avenir, belonging to the same company, in which the consumption of fuel, measured in the same way, was 5·4 lb. per I.H.P. per hour. This agreed very nearly with the account given of the Scotia, Anglia, and Cambria mail boats running between Kingstown and Holyhead, in which the consumption was stated to be 5·3 lb. per I.H.P. per hour. Reference was also made to Professor Rankine's experiments on board the Admiral, fitted with double cylinder engines, in which the consumption was said to be $2\frac{1}{2}\frac{8}{0}$ lb. per I.H.P. per hour, or nearly fifty per cent. more than that of the Kabyle, as determined by M. Moreau. Also, to some experiments on board the Algesiras, a French ship of the line, of 2414 I.H.P., when it was found that with the full pressure of the steam the consumption was 3·74 lb. per I.H.P. per hour, and with the steam cut off at one-third of the stroke 3·6 lb. per I.H.P. per hour. The author believed that the ordinary consumption of fuel in marine engines was above 6 lb. per I.H.P. per hour; that comparatively few worked so low as 5 lb., and none under $4\frac{1}{2}$ lb., taking the gross consumption for a whole year.

An examination of the tabular records of the experiments made with the two ships Sahel and Oasis, gave the following results in favour of the combined vapour engines. First, a weight and space available for 50 additional tons of cargo, or an increase of one-sixth; secondly, a diminution in the consumption of fuel of 40 per cent.; and thirdly, an increase of one-ninth in the speed of the ship. The attendant disadvantages were, the first cost of the apparatus, the difficulty of condensing the ether during very hot weather, the losses arising from leaks which occurred from time to time in the vapouriser, and the expense and danger of the liquid employed necessitating constant care and a more efficient engineer than an ordinary steam-engine. Still, notwithstanding all these inconveniences, the actual saving was such as to merit attention. The additional expense required to fit the Sahel with a combined engine instead of a common steam-engine would not exceed £4000. Such a ship on the African line could accomplish from twenty to twenty-four voyages per annum, or run from 20,000 to 24,000 miles, and economise, as compared to the Oasis, 1000 tons of coal, of the value of £1600. From this would have to be deducted the value of the ether consumed, say £409, and £400 as a sinking fund to pay off the extra expenses incurred, or together £809, leaving a net economy of £791. But to this must be added the profits arising from the additional cargo capable of being carried; this could not be estimated at less than £700, so that there resulted a net economy of £1491, a sum more than sufficient to pay an interest of 6 per cent. per annum on the capital required to purchase such a ship.

The number of accidents which had occurred during five years' experience had been but three. The first happened on board the ship France, when lying in the port of Messina. This arose from an escape of ether, caused by a workman having trodden upon and broken a weak copper pipe under the bilge water, and

Digitized by Google

which was therefore out of sight. The ether having accumulated in the engine-room, was accidentally ignited, when a great flame filled the engine-room and extinguished itself in a few moments without producing any disorder, or leaving any trace of the fire. The second accident, which caused one death, occurred on board the ship Brésil, when in the dry dock at Marseilles. This accident was also occasioned by a workman entering the engine-room with a naked light, against express orders, and setting fire to the gases of the ether floating in the room, the vapouriser being open at the time for cleaning. The third accident was the most serious, and the most fatal to the development of the system. This was the burning of the ship France, in the port of Bahia, before alluded to. It was now well known that this had been caused by discharging at night a number of cases containing ether, not belonging to the provision of the ship. One of the cases was broken, the liquid spread, and ignited at one of the lanterns, setting fire to the hold, at some distance from the engine-room. Thus, these accidents all occurred when the engines were not at work, when the fires were extinguished, and the ships were in port. No accident had happened to the ships while at sea, and no extra insurance had ever been paid on the ships on account of their containing ether, even after the burning of the ship France.

In conclusion it was remarked, that the difficulty of condensing the ether would not take place in latitudes where there was not an excessively high temperature, nor if a liquid with a higher point of ebullition was employed. The occasional leakage of the vapouriser was a purely practical defect, which would, no doubt, be easily remedied. As therefore a great economy of fuel had been shown to result from the combined system, it remained to be seen whether the inconveniences mentioned were such as to limit its general extension. It was thought possible that a cheap, non-inflammable liquid might be discovered, and that the cost of the apparatus might be still further reduced; as experiments made by Mr. Bramwell seemed to lead to the belief, that the surface of the vapouriser might be considerably decreased. The extensive scale on which the system had already been employed, and the favourable manner in which it had been reported upon by different engineers, was the author's reason for bringing the subject under the notice of the members. M. Du Trembley was most anxious that his invention should be better known to English engineers, in the hope that they would co-operate in removing the existing defects, and in rendering its application more certain and practicable.

THE PALACE OF THE PEOPLE, MUSWELL HILL, HORNSEY.

A project is on foot, having the sanction of many influential names, for erecting, in the most elevated and beautiful suburb of the metropolis north of the Thames, a building akin to that which adorns its southern vicinity, at Sydenham, and with a similar purpose in view,—the instruction and amusement of the masses. It is proposed to be placed within a short distance of the Hornsey railway station, on the Great Northern line; it will thus be easily accessible from all parts of London, while from its position it will command an extensive and beautiful prospect in every direction, as well as forming in itself an ornamental object in the landscape, The estate at Muswell Hill, comprising more than 450 acres of land, has been secured, and, after reserving all the land required for the palace and grounds, about 300 acres it is calculated will remain, to be available in other ways.

The designs for the building itself are at present on private view, but will doubtless shortly be made more public. They have been prepared by Mr. Owen Jones, the architect who was engaged, among others, on the Exhibition building of 1851; as well as on the palace at Sydenham. The drawings are complete in every respect, and, including the general plans and that of the site, occupy eighteen large sheets. Of the prevailing character it will be sufficient to explain that it resembles that of the building last mentioned, modified of course to suit avowedly the present requirements. In the centre of the building is a dome of 200 feet internal and 210 feet external diameter, springing at a level of 36 feet from the floor below, which is 12 feet above the general level of the building: it rises between four towers, and its parts are connected by galleries. The square block thus formed is 276 feet on each side, and is flanked by two naves, each with a clear area of 336 feet by 120, with side-aisles 72 feet wide. The ends of the building are 264 feet by 48; and, in continuation, are two semicircular colonnades, 120 feet in diameter within and 296 feet without: these it is intended to devote as refreshment courts. The extreme length of the building is 1296 feet; its greatest width, 492; the total area covered is—

	Feet.
On the ground floor	511,038
On the gallery floor	138,816
On the upper floor	91,008
	740,862

Galleries, 48 feet wide, run round the dome and naves; also across the ends: with upper galleries round the dome and at the two extremities of the building. The fall of the ground allows of an additional story, 48 feet wide, being contrived in the basement of the south side, which corresponds with the level of the railway station on the north side.

The central dome is intended to be appropriated to a winter garden, and the two naves are to be devoted respectively to a permanent exhibition of the works of industry and objects of commerce, and to those arts and sciences which direct and embellish the productions of industry. The area of each nave is divided by two main arteries, each 24 feet wide. In the centre of the industrial nave may be placed machinery in motion, and, on either side, fixed machinery, agricultural implements, and raw products; whilst in the galleries may be arranged the varied results of machinery aiding man in converting these products to his use.

In the fine art nave the various schools of art may be fully illustrated; and, in the galleries, divisions allotted to illustrations of mathematics, astronomy, physics, biology, &c.

To carry out more fully the plan of instruction, a lecture room has been provided, near the centre of the building. Its diameter is 216 feet; it is surrounded by corridors 24 feet wide, communicating with three sides of the building, and is calculated to hold 10,000 persons. Beneath the platform on which the lecture theatre stands is a railway station, in which passengers would arrive under cover, and ascend to the ground floor of the building.

The carrying out of this desirable scheme is proposed to be undertaken by a company, and in its aid the sympathy of the public is invited; the projectors, in their preliminary announcement, expressing their confidence "that an institution of so comprehensive and useful a nature, and accessible to so large a portion of the population of the United Kingdom, cannot fail to enlist the support of all those who are friendly to the cause of national education, and the healthful recreation of the people."

REVIEW.

The Year-Book of Facts in Science and Art. By JOHN TIMBS, F.S.A.—London: Kent & Co.

It is seldom one meets with so matter-of-fact a man as Mr. Timbs, or one who has the rare skill of detaching from the commonplace occurrences of life such portions as are of solid and permanent interest. His long connection with the literary world renders him a mine of information in himself, and one every way fitted to expatiate to others on "things not generally known." 'The Year Book of Facts,' edited by him, and which has now attained its twenty-first volume, is an additional proof of his researches and zeal in his favourite pursuit. It is replete with information gleaned from a variety of sources, and collated with great care, so that in a little book of less than 300 pages may be traced a useful epitome of all that has transpired during the past twelvemonths in the arena of science and art. The general heads under which these particulars are classified are:—Mechanical and Useful Arts, Natural Philosophy, Electrical Science, Chemical Science, Natural History (subdivided into Zoology and Botany), Geology and Mineralogy, Astronomical and Meteorological Phenomena. To these is appended a brief obituary list, with which the volume concludes.

On dipping into its pages we of course recognise many subjects which, either *in extenso* or in the quoted form in which they here meet our eye, have already found a place in our own volume in the mechanical and engineering section—this is particularly noticeable; we are induced, however, to copy the example, and, for the

Digitized by Google

benefit of our readers, borrow in return. The nature of the work does not admit, of course, the introduction of discussional subjects in general, and the articles themselves are necessarily varied and brief:

NEW BRIDGE, CHELSEA.

"This new bridge, connecting Chelsea with Battersea, was designed by Mr. Page, and is on the suspension principle. At the site chosen the Thames is 737 feet in width. The river is spanned by three spaces, the central being 352 feet between the piers, and the side ones 173 ft. 6 in. each; the two piers in the river are 19 feet wide each by a length of 86 ft. 6 in. The height of the caissons of the piers above Trinity high-water level is 7 ft. 6 in. Above the level of the top of the caissons the piers are surmounted by towers, constructed principally of iron. They diminish in plan to 9 ft. 8 in. by 4 ft. 2 in. at top, the whole being surrounded by a cradlework of cast-iron, upon which the rollers of the saddles work that carry the suspensory chains. Below the caissons the ironwork spreads out at the bottom on bed-plates, that rest upon York stone landings, below which are piles and concrete supports. Externally the whole of the piers are covered with an ornamental casing of ironwork. The point of contact of the suspensory chains on the towers is at an altitude of 51 ft. 8 in. above high-water mark; and the top of the finials that terminate the towers is 88 ft. 6 in. from the same level. The abutments of the bridge, both on the Chelsea and Battersea sides of the river, have each 'a relieving arch' in the centre, which serves the purpose of distributing the weight uniformly, the space between the arch and abutment being filled with concrete. The abutments as well as the piers rest firmly upon piles, which have been driven 20 feet beyond low-water mark. There are also piles driven at an angle in front of the mooring chamber as an extra security. The roadway and overhanging footways of the bridge are embedded in asphalte on a ground or foundation of cork and bitumen asphalte. On each side of the carriage-way is placed a tram for the heavy traffic. A very large amount of additional strength is obtained over the ordinary mode of construction that has hitherto been adopted in the formation of suspension-bridges, by the introduction of two longitudinal lattice girders of wrought-iron, one of which is inserted on each side, and separate the roadway from the foot-paths. At each end of the bridge are picturesque lodges, octangular in plan, the roofs covered with Portland cement, and their angles and summits adorned with appropriate terminations in terra-cotta. The four towers that rise over the caissons and piers in the river are highly picturesque in form, and are entirely constructed of iron, except 18 feet of their upper portions at top, which are of moulded copper, which is gilded and painted to resemble light-coloured bronze. The summits of the towers are crowned with globular lamps."

VICTORIA BRIDGE, CANADA.

"Although the Britannia-bridge represented the most scientific distribution of material which could be devised at the date of its construction, it has since been improved upon by the same engineer in the Victoria-bridge, now in the course of construction across the river St. Lawrence, near Montreal. The Victoria-bridge is, without exception, the greatest work of the kind in the world. For gigantic proportions and vast length and strength there is nothing to compare with it in ancient or modern times. The entire bridge, with its approaches, is only about 60 yards short of 2 miles. It is five times longer than the Britannia-bridge across the Menai Straits, seven-and-a-half times longer than Waterloo-bridge, and more than ten time longer than the new Chelsea-bridge across the Thames! The Victoria has not less than 24 spans of 242 feet each, and one great central span—itself an immense bridge—of 330 feet. The road is carried within iron tubes 60 feet above the level of the St. Lawrence, which runs beneath at a speed of about 10 miles an hour, and in winter brings down the ice of some 2000 miles of lakes and upper rivers, with their numerous tributaries. The weight of iron in the tubes will be upwards of 10,000 tons, supported on massive stone piers each of solid masonry. So gigantic a work, involving so heavy an expenditure, has not been projected without sufficient cause. The Grand Trunk Railway of Canada—one of the greatest national enterprises ever entered on—is upwards of 1100 miles in length, opening up a vast extent of fertile territory for the purposes of future immigration, and by connecting the settled provinces of Western Canada with the seaboard states of the American Union, calculated to afford full scope for the development of the industrial resources of that magnificent colony. Without the Victoria-bridge the system of communication would have been manifestly incomplete; the extensive series of Canadian railways on the north side of the St. Lawrence, terminating opposite Montreal, would, for all purposes of through traffic, be virtually sealed up during the six months of the year that the St. Lawrence is closed against navigation by the ice, and the Grand Trunk system must necessarily have remained to a great extent nugatory, in consequence of the province being cut off from the coast, to which the commerce of Canada naturally tends."

GRAND TRUNK RAILWAY OF CANADA.

"Messrs. Peto, Brassey, and Betts, the contractors for the Victoria-bridge at Montreal, belonging to this company, have progressed during the past summer at a rate that gives hope they may be able to open it for traffic in October 1859, instead of on the 1st of January 1860, in accordance with the terms of their last contract. It is estimated that if these two or three months can be gained, they will probably make a difference in the receipts of the company for the second half-year of 1859 of from 70,000*l.* to 80,000*l.* The number of hands at the work on the 1st of October 1858, was 3231, apportioned as follows:—fitters and smiths, 153; riveters and platers, 121; carpenters, 280; masons and stonecutters, 326; painters, 19; labourers, 1331; raftsmen, 49; boys, 75; crews of steamers and barges, 450; men employed at the Canada works, Birkenhead, in the construction of tubes, 477. There were also employed on the bridge 142 horses. The bridge consists of twenty-four spans of 242 feet each, and one in the centre of the river of 330 feet. The spans are approached on each side of the river by a causeway, each terminating in an abutment of solid masonry 240 feet long and 90 feet wide. The causeway from the north bank is 1400 feet long, that from the south bank is 700 feet long."

BRITISH RAILWAYS.

"At the present moment we learn, from returns recently published, that we have in this country alone 9500 miles of railway executed and in actual operation; and taking, at a rough calculation, one locomotive engine with a force of 200-horse power to every 3 miles of railway, and assuming each to run 120 miles a day, we thence calculate the distance travelled over by railway trains to be equal to 380,000 miles per diem, or the enormous distance of 138 millions of miles per annum, a space measuring the distance of the planets, and beyond the conception of those unacquainted with figures. To transport engines and trains this distance requires a force equivalent to that of upwards of 200,000 horses in constant operation throughout the year."

PREVENTING DOWN DRAUGHTS IN CHIMNEYS.

"Mr. H. Wetherell, of Upper Chapman-street, St. George's East, has patented a singular but very efficient apparatus for the above purpose. It consists of a valve and valve-seat made and acting as hereafter described. He fits a seat in metal or other suitable material at any desired height in a chimney or flue, and above the seat suspends a ball filled with some gas lighter than the atmospheric air. The ball offers no impediment to the passage upwards of smoke, vitiated air, or any other ascending current; but any descending current is effectually stopped by the valve, which is thereby forced down on to its seat."

HYDRAULIC CEMENTS.

"A Paper on this subject has been submitted to the Paris Academy of Sciences by M. F. Kuhlmann, showing the advantages to be derived from the combination of silicates with mortars and cements in general, and especially with those that are intended to resist the action of sea-water. It is well known that the first effect of water on cements is that of forming hydrates; after which a gradual contraction takes place, producing a degree of hardness, which increases in proportion as the contraction is slower, and there is more silex or alumina in the cement. Now, M. Kuhlmann has observed that if alumina or its silicate, or else magnesia, whether caustic or carbonated, be kneaded into a paste with a solution of silicate of potash or soda, the compounds resulting therefrom will bear a perfect resemblance to the natural silicates, such as feldspar, talcous slate, magnesite, &c., and will by repose and slow contraction become hard and semi-transparent, resisting in a high degree the corrosive effects of water. If slaked lime be added to the said compounds they acquire the properties of hydraulic cements. M. Vicat, jun., having shown that calcined magnesia added to a cement would resist the action of

Digitized by Google

Digitized by Google



March 1854 J.R.Johnson

THE CHURCH OF ST MARY TOLMERS, HERTFORDSHIRE.

MESSRS LANDER & BEDELLS, ARCHTS

Gt James St Bedford Row

Digitized by Google

sulphate of magnesia, M. Kuhlmann has endeavoured to turn this observation to account by mixing calcined dolomites (which contain magnesia) with mortar, with the addition of alkaline silicates. This composition he finds very advantageous, since most of the salts contained in sea water must contribute towards the preservation of such cements. In fact the chloride of magnesium, as well as the sulphate of magnesia, will be decomposed and form a layer of silicate of magnesia on the surface of the cement; in the same manner the sulphate of lime must, being in contact with the silicate of potash or soda, form a silicate of lime; and all these silicates strongly resist the action of sea-water. As for sea-salt, which is a chloride of sodium, M. Kuhlmann proves that in the proportion in which it exists in sea-water it will slowly decompose the silicate of potash contained in the cement, and leave the silex free. The compositions proposed have therefore the singular property, not only of resisting the corrosive qualities of sea-water, but of actually becoming more insoluble the longer they are in contact with it. A cement composed of 30 parts of rich lime, 50 of sand, 15 of uncalcined clay, and 5 of powdered silicate of potash is recommended by M. Kuhlmann as having all the requisite hydraulic properties, especially for cisterns intended for spring-water. In marine constructions care should be taken to add an excess of silicate to those portions of cement which are exposed to the immediate contact of the sea."

Among subjects less within our own province, we may direct attention to those upon the Atlantic Telegraph, the Electric Telegraph Improvements, the great Solar Eclipse of last March, and Donati's Comet.

BUILDING AND SCULPTURE MATERIALS IN NEW SOUTH WALES.

There was a time when, judging merely from the barren soil and the brittle sandstone about Sydney, even the geologists of England thought that there was not a particle of any useful mineral in the whole of the Australian continent. Still, marble has been worked in New South Wales ever since the year 1832, by Mr. Clewitt. The red, black, white, and yellow varieties were especially praised by Mr. Clewitt, but they formed merely subordinate strata in the slate and wacke formation of the Razor-back Mountain, about thirty miles south of Sydney. As we proceed further south primitive formations make their appearance, and there are mountains of primitive (crystallised) limestone on Mereno Downs, near an acidulated cold spring, discovered in 1834. Here slabs of every size of this Australian Carrara marble will be ready for the statuary and architect as soon as a railway will connect these fertile downs with Twofold Bay, and as soon as that bay will have the necessary commodities for shipping. White Houses and Capitols may then be built, which will astonish the traveller—not to be matched, probably, in any other part of the world.

In some of the mountain tiers which stretch into the Downs of Mereno (being extensive plains of various shapes), and which bear vestiges of volcanic action, materials for high architectural ornamentation and statuary of surprising beauty and extent are to be met with. Here the finest syenite, serpentine, and porphyry cheer the sight of the traveller, and remind him of the fact that even in these hitherto unwrought and neglected wilds the germs of a future high civilization and a high pitch of art are laid. Speaking commercially, a huge slab or column of serpentine, porphyry, or syenite will change what might have been ballast hitherto into a rather valuable cargo.

Plunging further south into the heights of the Australian Alps, granites of all colours and granulation are to be met with, some flesh-red ones, resembling those of Egypt; and it may be soon the case that the hitherto log huts of the wealthier squatters and sheepowners may be changed into cottages built of granite—a very economical building material when labour is not too dear, as many of the houses, even in the outskirts of Rio de Janeiro, are built of that material.

There has been purchased, some years ago, a collection of Australian rocks by the trustees of the British Museum, where all the before-mentioned rocks are to be met with.

CHURCH OF ST. MARY TOLMERS, HERTFORDSHIRE.

(With an Engraving.)

This church is situated near the village of Newgate-street, and stands on the estate of Thomas Mills, Esq., M.P., by whom it was first erected, and has recently been greatly enlarged and improved. The west front, tower, transepts, and vestry are entirely new, and the old portions of the church have been faced with stone, and made in other respects to correspond with the new portions.

The ceiling has been removed, and diagonal boarding on the back of the rafters substituted. The roof is stained and varnished. The benches are all of wainscot, and of good design, and the pulpit of stone, elaborately carved. The effect of the interior is greatly heightened by the windows, which are filled with stained glass, by Messrs. Gibbs, of London, consisting for the most part of subjects from Scripture history. There is also a fine organ, built by Mr. Walker, in a case appropriately designed and executed in wainscot. The tower doorway forms the main entrance to the church, the floor being composed of Maw's tesselated pavement, specially designed for this purpose. In the upper portion of tower there is one bell. The boundary wall is of stone, surmounted by an iron cresting, relieved by gilding, the gates being of oak.

So complete is the restoration that the church has the appearance of being an entirely new building. It is in the Early English style, and gives additional attraction to a locality which naturally has many charms.

The outlay has been about £2800, and the works have been admirably executed by Messrs. Dove, Brothers, of Islington, under the superintendence of the architects, Messrs. Lander and Bedells, who have also carried out the works in connection with the schools, mansion, and buildings adjoining.

ON DESIGN IN INTERIOR ARCHITECTURE.*

By Sydney Smirke, A.R.A.

Last year I had the honour of addressing to you some remarks on the subject of form as it affects design in exterior architecture. I propose now to submit to you the result of my experience and reflections on design in interior architecture. These two subjects readily admit of separate consideration, and, indeed, almost demand it; for the aim and purposes, as well as the means, of the designer in each case are widely different. In determining the external features of a building, we have to consider, besides the character of the building itself, various collateral circumstances, such as the nature of the site, the character of the surrounding scenery, and the aspect of the architecture with which our work may be associated; and it is the contours or bounding out lines of the building we design that in great measure determine its effect. It is far otherwise with internal architecture: there we may disregard any collateral circumstances, and are enabled to limit attention to the individual character of our subject.

In designing the interior architecture of a building, there arises, however, a new and peculiar source of difficulty. Considerations of convenience come in to embarrass our pencil and to complicate our difficulties. Architectural effect and fitness of arrangement will often militate most inopportunely against each other. We must needs have a door, perhaps, exactly where we would fain have had solid masonry; and light, perhaps, can only be obtained from the east, whilst æsthetic considerations urge us to prefer the west. In fact, to reconcile these two important yet often incongruous objects, forms one of the severest trials of architectural skill.

The art of conveniently arranging the various parts of a plan so as to fully adapt them to their special purpose, is truly one of primary importance to the architect. It is indeed an obvious truth, that unless our plan be such as to afford a convenient collocation of its several compartments, and unless these compartments themselves are well adapted to their respective purposes, all the rest of our labour and our art will be idly and wastefully expended. To lay down a good plan, therefore, becomes the first duty of an architect, and demands his first and most earnest attention.

* Lecture delivered at the Royal Academy.

Digitized by Google

It is not, however, on an occasion like the present that this subject of a convenient arrangement of a plan can be entered upon with advantage. Such a consideration is too technical for our present purpose, and comprehends too wide a range of subject for the time at our disposal. I will, therefore, on this point confine myself to the general observation, that simplicity and directness are cardinal virtues in all architectural arrangements. Avenues should be as straight, as short, and as obvious in their course as possible. The rules for the moral conduct of a man are very applicable to this branch of our art: his ways should be clear and obvious; free from ambiguity and uncertainty,—without tortuous or dark places. When a turn is necessary, let it be one which cannot be mistaken. There should be no seeking for the way in or out.

The first impression on entering any building should be such as is becoming its special purpose. The temenos of a Greek temple was well calculated to give an impressive air of sanctity to the temple itself, by excluding from view all incongruous and mean objects; enhancing, too, the architectural effect of the façade by surrounding it with suitable accessories.

A similar feeling, perhaps, led the early architects of Christendom to form that peculiar forecourt or atrium in front of the haos, of which but few examples now remain, although probably this atrium was an essential part of every Early Christian church. The basilicas of San Ambrogio, at Milan, and of S. Clemente, at Rome, are very interesting and nearly complete examples. There can be little doubt that the builders of that devote age were influenced by subjective considerations of this kind, although the ritual appropriation of this portion of the building was to receive the catechumens of the church, and to afford a suitable and becoming place wherein the candidates for baptism might present themselves. At all events, a very powerful effect must have been produced upon the eye and mind by thus shutting off from view the outer world, and concentrating attention on the more sacred structure about to be entered.

It was, perhaps, a similar motive—a legitimate artifice for the purpose of strongly impressing the mind of the worshipper—that led our old church builders usually to form their doorways of very moderate dimensions. Great emphasis was ordinarily given to the western, and often to the lateral doors, by exterior decorations, and by recessed and gabled porches, often rising to a height of great grandeur; but the actual opening of the doorway will generally be found comparatively low. The natural effect of this is to produce, as it were, a surprise, and by the contrast to make more impressive the extent and loftiness of the structure within.

Turning to domestic architecture, we shall not fail to recognise the efforts made by the early Italian architects, in designing the entrance-halls of their noble palazzi, to secure the benefit of a favourable first impression. At Venice, especially, these halls are of large dimensions, and are treated in a broad and grandiose style, sparing of mere surface ornament, but usually embellished with ancestral statues and warlike trophies; of which one of the most striking, as well as the most frequent, are the gigantic bronze lanterns taken from an enemy's galley.

Beyond the entrance-hall of domestic buildings in Italy we sometimes meet with those inner halls, which, perhaps, owe their origin to the example set by Palladio in his well-known Villa Capri, where a central hall of large size and graceful proportions gives means of communication with all the principal apartments, itself sufficiently removed from the exterior to admit of being used as a saloon of general domestic resort; a happy idea, that was alike productive of beauty and convenience, not only in the land of its birth, but in the interior arrangement of many of our own country residences.

On turning to the ground plans of some of our own princely structures, we shall perceive how largely English architects availed themselves of this feature of Palladian art. Somewhat analogous to these inner halls are the cortili, which form so usual and so graceful a feature in Italian palazzi. These cortili may probably be regarded as lineally descended from the central peristyle of the Romans, which, as we see at Pompeii, formed the ordinary place of resort for the residents and visitors, as well as being a means of general communication with the adjacent apartments. The cloisters of conventual buildings were also, apparently, an amplification of the same idea, and may claim a similar descent, although used not as a forecourt like the atrium of a basilica, but rather as a collateral adjunct, well adapted alike for exercise and for contemplation. Whatever the phase of art, whatever the mode of treatment—whether arcaded, whether columnar, or both—these enclosures afforded occasions for most picturesque and pleasing designs. At those interesting remains of Roman magnificence, called the Villa of Mecænas, at Tivoli, we find a remarkable instance of the union of an arcade and colonnade, forming a cloistered ambulatory; and examples such as this became the parent of a host of beautiful arrangements in after times, by which the greatest possible amount of variety of outline and *chiaroscuro* was obtained.

We must proceed now to an important feature in the plan of every structure of moderate height destined for man's occupation,—I mean the staircase.

In the design of this often very picturesque feature, it must be admitted that we owe but little to any examples of antiquity. In temples, staircases of ample size were obviously not required; but I am unable to cite any instances of an internal staircase of striking effect or dimensions in even any Classical remains. Magnificent flights of steps no doubt occur in exterior architecture, and in Belli's 'Description of the Greek Theatres of Crete,' translated by my able friend Mr. Falkener, as well as in other examples, we see evidences of the existence of double returning flights of stairs, similar to those in frequent use in modern architecture, having each flight enclosed within solid walls, and setting us an example of sound and solid construction, well worthy of careful study in the execution of our own public buildings. The newel stair, so characteristic a feature in the plans of a subsequent age, was certainly of purely Greek origin.

A perfect example exists, in good preservation, among the ruined temples at Selimentum. Its dimensions, however, are small; the diameter of the circle which contains it being but 6 ft. 4 in.,—dimensions which were subsequently greatly exceeded in the similar spiral stairs within the monumental columns of ancient Rome. The domestic architecture of Rome seems to have required little aid from interior stairs; and even in so sumptuous a building as the Coliseum, where many thousands of spectators had to be provided with ready means of access to very high levels—a building, too, erected when Roman power and art were in their zenith, expressly to gratify the extravagant love of splendour and display which characterised the Roman people—we find no indication of any fine staircase. Among the buildings which remain to us of the earlier middle ages, it is still difficult to point to any notably fine stairs. Highly effective flights, no doubt, occur; striking examples occur at Assisi and at the cathedral in Lucca, where flights of stairs 7 or 8 feet wide occur, with marble balustrading, sufficing to show that mediæval builders were, to some extent, alive to the fine effects attainable by the artistic treatment of this portion of their plan.

Still, these examples are of rare occurrence. It will be difficult to refer to any case in this country of equal importance to that in the cathedral close at Canterbury. The newel stairs, of which so many examples remain, as at Dover Castle and Tamworth church—the latter presenting, I believe, an almost singular example of a double spiral stair round one newel—were certainly the most usual form of stairs in buildings, even of the most important character, during the whole middle age period; so much so, indeed, that the detached turrets which contained these newel stairs became one among the most prominent features of domestic architecture throughout Europe during that period. It is needless to point out the numerous examples that everywhere remain, but I would say that perhaps no city contains more remarkable ones than that so rich in scenic effects, viz., Nuremberg. Wherever this turretted staircase occurs, it always constitutes a pleasing and striking object, imparting an agreeable variety of outline to the architectural composition. As peaceful arts advanced and men ceased to look for security in embattled buildings, the artistic eye of the builder soon perceived the opportunities that were afforded by interior flights of stairs for pleasing and pictorial effects. Nor could he be insensible to the extreme inconvenience of a newel staircase which, whatever its width, can necessarily offer but one place where the treads and risers are of proportions at all convenient to persons ascending or descending. In the quiet times of the later Tudors, staircases in this country began to assume their proper position and character; and there is no part of our old Elizabethan mansions on which the builders seemed to have dwelt with more pleasure, or on which they were more wont to exercise their fancy, than the staircase.

But whilst those fantastic works were in course of erection which we see at Crew Hall, Hatfield, and many other places, the

Digitized by Google

more polished artists of Italy were erecting staircases of magnificent proportions and bold character, although of a totally different aspect. This is a phenomenon of art well worthy of observation. At the very time when those rude and sometimes grotesque works were being executed here, to which I have been alluding, there existed in that land of art staircases designed by the great Italian masters which were consummate models of grace and refinement, like that at St. Georgia, in Venice, by our great master Palladio. From these our Elizabethan and Jacobean works differed as widely as these latter did from the works of their English predecessors. The genius of each people is well typified in this diversity. Broad, bold, irregular, and unrefined, —such were the characteristics of the one school; whilst the staircases contemporaneously erected by the other school were grave, symmetrical, and extremely simple, although of much bolder dimensions.

I am well aware that the study of this contrast may lead different minds to very different conclusions. The picturesque and quaint exuberance of our own old manner of desiguing the balustrading, for example, seems calculated to win the admiration of the mere painter more readily, perhaps, than the plainer and more sober balustrades of the Italians; while a different feeling may prevail in the colder temperament, which is forced, as it were, on the architect by the very nature of his profession, working as he does not on canvas, but in solid masonry.

That this more simple and less ambitious character of balustrading was affected by mediæval architects of the best period, as well as by the architects of the Palladian age, is a fact that may lead us to the conclusion that, much as we may admire, we must as architects be slow to imitate the pictorial wantonness of design prevalent in the sixteenth and seventeenth centuries in this country.

As time advanced, the sobriety of manner which distinguished Italian architecture in the fifteenth and earlier part of the sixteenth century gave way, and staircases began to be designed in a capricious and fantastic manner. An excess of freedom and a wonderful power of execution led to the erection of staircases that are fit rather for the study of the scene-painter than for that of the architect. Greatness of dimensions, however, was a merit to which all were alive, and we accordingly find in Italy staircases of a size sometimes almost extravagant. The staircase in the Albergo dei Poveri, at Genoa, is 115 ft. by 63 ft.; and that in the Royal Palace at Naples is no less than 163 ft. by 85 ft.

The Renaissance school, of which we are treating, employed two very different types of staircases, each perhaps equally susceptible of beauty. One wherein both ends of the steps are inserted into and supported between two walls, as at the Cretan theatres already named; the other, where only one end of the steps was inserted into the walls, the opposite end simply resting on a wall or other sufficient support. As notable and familiar examples of the first type, I might point to the principal staircases at Versailles, Fontainebleau, and the Louvre, and to a host of Italian examples which it would be superfluous to enumerate. This form of stairs is capable of great dignity, as well as of great beauty, but it has some inherent inconveniences. The raking soffit of each flight is a source of difficulty in design, and gives rise to some unpleasing appearances: it is wanting in lightness and freedom of effect, and is open to this practical objection— that persons ascending and descending do not see each other until they abruptly meet on the landing. The staircases of the second type are, on the other hand, far more free and open, and the eye expatiates over the whole area of the staircase at once. It is needless to multiply examples of this latter familiar form. The elegant work of Palladio at Venice, already named, and the stupendous staircase already referred to at Naples, are well known illustrations of this type.

I might add perhaps, as a third variety of staircase, those wherein there is no turn, and where the stairs extend in a continuous straight line,—a form of plan by no means to be recommended, except where the height to be attained is very moderate, or where the width of the staircase is of the most ample kind, as at the Royal Library at Munich. The Scala Regia, in the Papal Palace at Rome must however be admitted to be an example presenting an extremely striking architectural scene. The proportions are colossal, and the flight is flanked on either side by a stately colonnade. The effect of this staircase is artfully heightened by a very peculiar expedient, which, as far as I know, is without a precedent. The flanking walls of this staircase are not parallel, but gradually and imperceptibly approach each other, the width at one (the lower) end being 10 feet more than at the other. The result of this is, by an illusion, to prolong the perspective, and to increase the apparent length of the colonnade to the view of a person approaching the state apartments—an architectural fraud, ingenious it may be admitted, but which I cannot recommend to your imitation.

It is, I think, to the second type of staircase that I would point as that which most deserves your attention. Schenkel's great work, the museum at Berlin, affords a favourable illustration of it; and a still more colossal staircase at the same museum has been recently executed by Stüler. The dimensions on the plan are about 140 ft. by 70 ft.; the walls affording, of course, a vast expanse of surface for the frescoes of Kaulbach and others. Munich also furnishes various fine examples, which the architectural student will do well to observe.

The principal error to avoid in these great open staircases is any appearance of tediousness in mounting. It should never be overlooked that the great, indeed the sole, object of a staircase is to facilitate our way upwards or downwards, and no display of architecture will reconcile us to any unreasonable amount of manifest indirectness in our upward or downward course. Those large, straggling, tedious stairs, up which we are occasionally obliged to travel, interrupted by perpetual landings,—and which, by following in their turnings all the four sides of the staircase, seem to lead us in any direction rather than that we desire to take,—are at once unsightly and inconvenient.

Before I quit the subject of staircases, I desire to commend to your observation and study the opportunities that a simple flight of even a few steps afford of producing an agreeable effect. It would be easy to multiply illustrations, but I will confine myself to two or three very simple instances occurring in that land of art—Italy. At the entrance into the Ospedale dei Incurabili, at Genoa, some local circumstances imposed on the architect the adoption of a very indirect line, the public street not being at right angles with the direct line of access to the interior of the hospital. So far from submitting to this awkwardness as a necessary evil with ignominious resignation, the architect struggled successfully to overcome the difficulty, and to give an apparent, although he was unable to give a real, symmetry to the plan, by the somewhat picturesque arrangement shown in the drawing.

To descend to a still humbler illustration, I would adduce an instance which I chanced to observe in a small and very unpretending house at Bologna. In a straight passage of moderate width it was necessary to rise 4 or 5 feet. The most convenient place for the steps required for this purpose was in the middle of the passage. The natural course for an uninventive mind would have been to adopt the very plain and prosaic course of placing so many parallel steps in a row, and so to get the passenger up and onwards in the simplest and most inartificial way. But such a mode of proceeding would ill accord with the æsthetic views of an Italian artist of the sixteenth or seventeenth century. He broke his flight of ten steps into two flights of five steps by a landing, with a short piece of ornamental parapet on either side, and thus not only gave these few steps a positively ornamental effect, but really assisted the passer both up and down, by affording a means of intermediate support.

I cannot refrain from pointing to a third example of a like nature, which attracted my notice at a convent in Rome. Bernini, who was its author, belonged no doubt to a debased school, but he was an artist of excessive boldness, and indeed vigour; his principal aim seemed to be to avoid insipidity at any cost. In this little work he entailed, it is true, upon all succeeding ages, as long as his staircase may be used, a constant and never-failing source of inconvenience. But he achieved his great object of avoiding the abhorred simplicity of a straight flight, and produced a highly pictorial effect with very small means and within a small compass. Do not imagine that, in pointing out to you this example, I am advising you to follow it: but such instances are suggestive, and we may frequently observe that in contrivances of this nature, insignificant and unobtrusive though they be, a really inventive talent displays itself.

(To be concluded in our next.)

The Royal Albert Bridge, Saltash.—Mr. Brunel's bridge crossing the Tamar is completed, and the first locomotive passed over it on the 26th ult. It is anticipated that the Cornwall Railway will be open for traffic by the end of April next.

Digitized by Google

THE MEDALS OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

At a special meeting of the Institute, held on the 14th ult., the royal medal for the year 1858 was awarded to Mr. G. G. Scott, subject to her Majesty's sanction.

The silver medal of the Institute was awarded to a critical essay on the Architecture and Genius of Sir Christopher Wren, under the motto "*In Memoriam.*" This is at present anonymous.

The Institute medal, with five guineas, for the best illustrations of a Mediæval building in Ireland, Scotland, or Wales, was awarded to Mr. Edward Hughes, of Chester,—motto, "Caer Lleon,"—for a restoration of Kilmallock Abbey. To Mr. D. Paton Low, for restoration of Torphichin Queer, Linlithgowshire, honourable mention.

The Soane medallion, for a design for a circus for equestrian performances, to Mr. Thomas Vaughan, junior,—motto, "Hope for the future gave energy to the past."

The student's prize (books) to Mr. W. T. Sams, for design for a riding-house.

NOTES OF THE MONTH.

Dry Dock, Port Louis, Mauritius.—'The Overland Commercial Gazette,' Port Louis, Mauritius, 27th Dec. 1858, contains the following, which we extract:—We have the satisfaction of announcing that to facilitate the recently established mail service between this Port, Australia, and the mother country, the Mauritius Dock Company, have commenced the excavations for a vast dry dock, to afford every facility for repairing such noble vessels as we shall have calling shortly at our port (Port Louis). The size of the dock is to be 350 feet long, 80 feet extreme breadth, 60 mean and 40 feet minimum breadth, depth 22 feet: in fact, capable of easily taking in such magnificent vessels as the Duke of Wellington, of 3756 tons, length 278 feet, length of keel for tonnage 202 feet, depth of hold 24 feet, breadth 62 feet. H.M. steam frigate Mersey, length 336½ feet, length of keel for tonnage 254 feet, breadth 52 feet, burthen 3726 tons. H.M.S. "Boscawen," which was lately here, is 2212 tons, length 213 feet; such a vessel would appear like a longboat in the new dock. The most important fact is, that merchant ships of all sizes can be taken into dock and immediately repaired. The pumping machinery is being constructed by Messrs. Gwynne and Co., engineers, London, whose names stand so favourably before the public. Engines of 100 horse power will work three centrifugal pumps, *each* discharging 12,000 gallons of water per minute; and the dock when full containing 13,000 tons of water, will be emptied in 2½ hours. Besides these pumps, a smaller one worked by a separate engine will keep the dock dry during repairs to vessels. The company have in addition, a forge and every appliance for the repairs of iron vessels,—this fact cannot be too widely known. The contractors have engaged to finish the excavations in a year, but nine months will probably suffice for the reception of vessels.

New Theatre Scribe, Turin.—This new theatre has been built after the plan of M. Bollot, and is said to be a model in its way. The building consists of four tiers of boxes, all furnished with a saloon, to the number of 100. The theatre thus forms a semicircle, topped by a gallery, which, like the pit, can contain 400 persons, the whole theatre accommodating 1600 persons. The fine decorations of the interior, white and gold, are by M. Aliberti, and the ceiling is painted by M. Sereno, presenting a fine allegory of the Muses and the Olymp.

Denbigh.—A fine specimen of stained glass has been inserted in the east window of St. David's Church, Denbigh, in memory of the late Mrs. Henry Tatlock, who resided in the neighbourhood, and whose liberality among those who needed it will long be remembered. The window is about 24 feet high and 12 feet broad, and has been painted by Mr. Ballantine, of Edinburgh. It is of three lights, with tracery in the head. Each light is divided into two compartments; the three upper of the series represent the subjects of Faith, Hope, and Charity; the lower divisions illustrate three of the acts of mercy—"Thirsty," "Naked," "Sick." In the tracery above are figures of angels holding scrolls, on which are inscribed appropriate texts.

Monument to Mozart.—As the exact place where this great composer has been buried is not known, a strange expedient has been resorted to for giving his mausoleum an approximative locality. It is that the monument will have such a broad base as to cover a number of contiguous graves. A pedestal of granite 8 feet high will support the mourning statue of Polyhymnia, made of bronze. The four sides of the pedestal will receive the bronze medallion of Mozart and suitable inscriptions. The plan has been made by Hans Gasser, and the monument is in course of construction.

Railway over the St. Gothard.—The engineer, M. Luchini, has completed plans for a railway through this alpine pass. According to two lines proposed, there would be either 2000 or 7000 metres of tunnelling required, the expenses being from 46 to 60 millions of francs.

Unwholesomeness of Lights.—Recent experiments have proved that lights of equal intensity obtained from different materials require very different lengths of time to generate the same quantity of carbonic acid. The following is the relative time required by the common materials: olive oil 72 minutes, Russian tallow 75, common (French) tallow 76, whale oil 76, stearic acid 77, wax candles 79, spermaceti 83, gas from the common coal 98, gas from fat or cannel coal 152 minutes. Coal gas therefore, and especially gas from the cannel coal, is the least unhealthy of all ordinary lights; which is contrary to the usual opinion.—*Cosmos.*

Florence.—New Building.—The progress of the arrangements for the new front of the Cathedral (Duomo) is satisfactory, and it is expected that the particulars of the competition will appear shortly. The front of the Santa Croce is proceeded with according to the plans of Cavaliere Matas. The materials are mostly taken from Prato and the Marenime, and this minor work is a good prelude to that of the cathedral. Other restorations also are in progress—as that of Or San Michele, which, together with the restoration of the Tabernacle, is nearly completed. But it is especially the Palazzo Pretorio or del Podesta that is most carefully restored; and the Cavaliere Passeini has of late published a history of this most important law court of Florence.

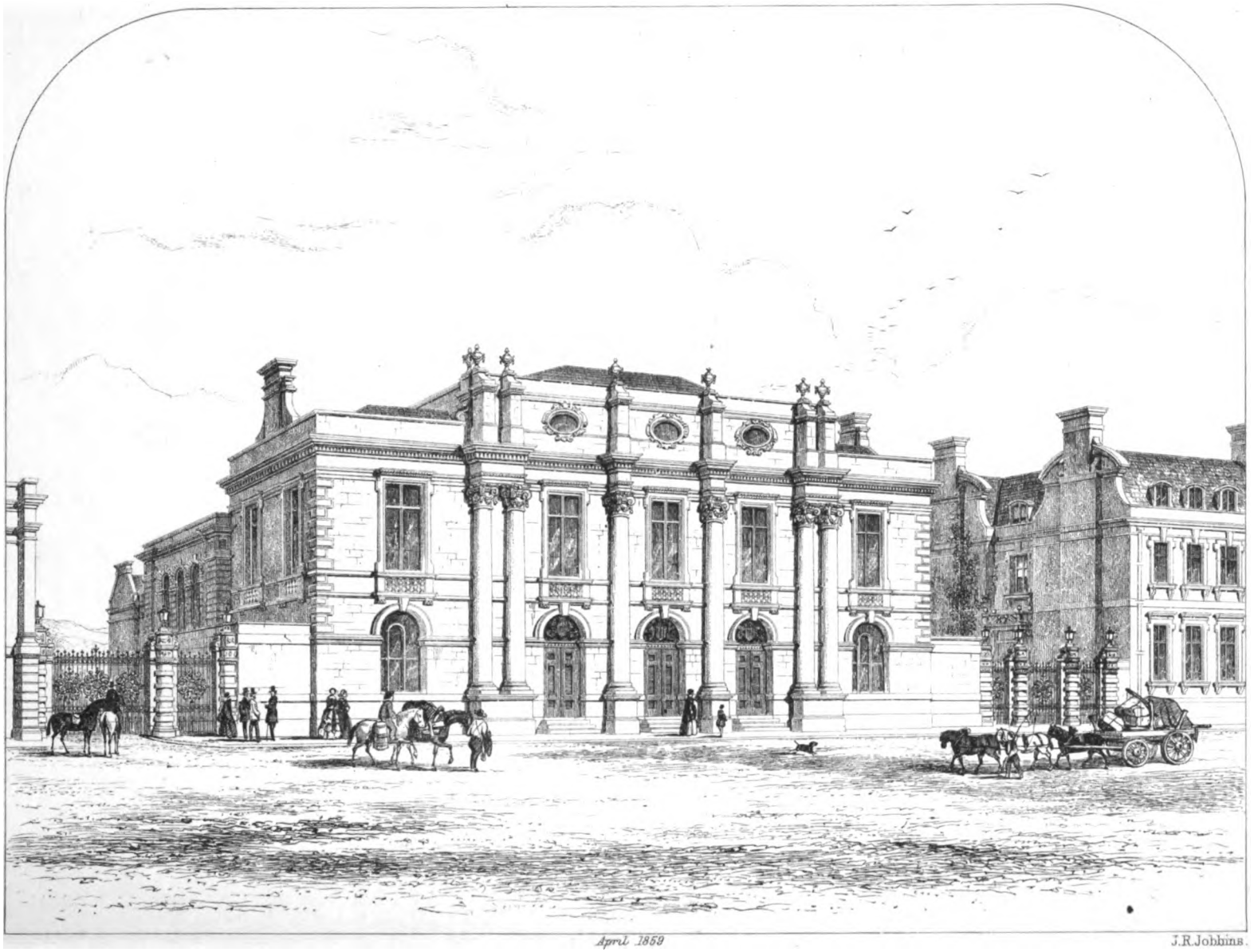
Enamelling Iron.—A very simple method of coating iron with an enamel of glass is a desideratum. In the following process the iron articles are first thoroughly scoured with sand and dilute acid, then washed and dried. Their surfaces are then covered with a thin coat of gum arabic laid on with a brush, and over this the enamel powder is sifted, until all the surface is covered to a certain depth, according to the thickness of glaze desired. The articles are now put into an oven heated to 212 degrees, and completely dried; after this they are put into a furnace and raised to a red heat, which melts the powder, and it forms the glazed surface. They are now removed to a closed chamber, when they are allowed to cool slowly, and are then annealed. The glazing powder for white enamel is composed of 130 parts of powdered flint glass, 20 of carbonate of soda, and 12 of borax. These substances are fused in a crucible and reduced to powder. Some glazes contain oxide of lead: they are dangerous to employ for culinary vessels.

Holland.—Great Engineering Works.—A stupendous work is going on in Holland—the embankment of two inlets of the sea,—and this converted into a canal navigable for the heaviest craft. By this operation 12,000 hectares of the finest soil will be obtained on the coast of the Scheldt. This canal will transect the Sud-Beveland island, between Hanswerd and Wemendinge. It will have a length of ten kilometres (6½ miles), with a tramroad on each side, aqueducts for taking off the superabundant water, &c. At both ends of the canal will be sluices, and a wet dock of 1000 metres surface. The dams will be four metres above high-water mark. A double line of rails will reach from Vliepingen to Bergen-op-Zoom, built on a *pilotis* ten metres broad. This work will place Vliepingen in immediate communication with all the railroads of Germany.

The new Railway Station of the Chemin du Nord, Paris.—The changes proposed in this huge structure are to the effect that the new entrance, instead of opening in front of the Rue de St. Quintin, will open into the Rue de Dinan, which will be converted into a large boulevard of 50 metres, and ending in a square formed by the Boulevard du Nord and De la Fayette. Every opportunity will be seized for improving the adjacent localities of this part of the French capital.

Digitized by Google

Digitized by Google



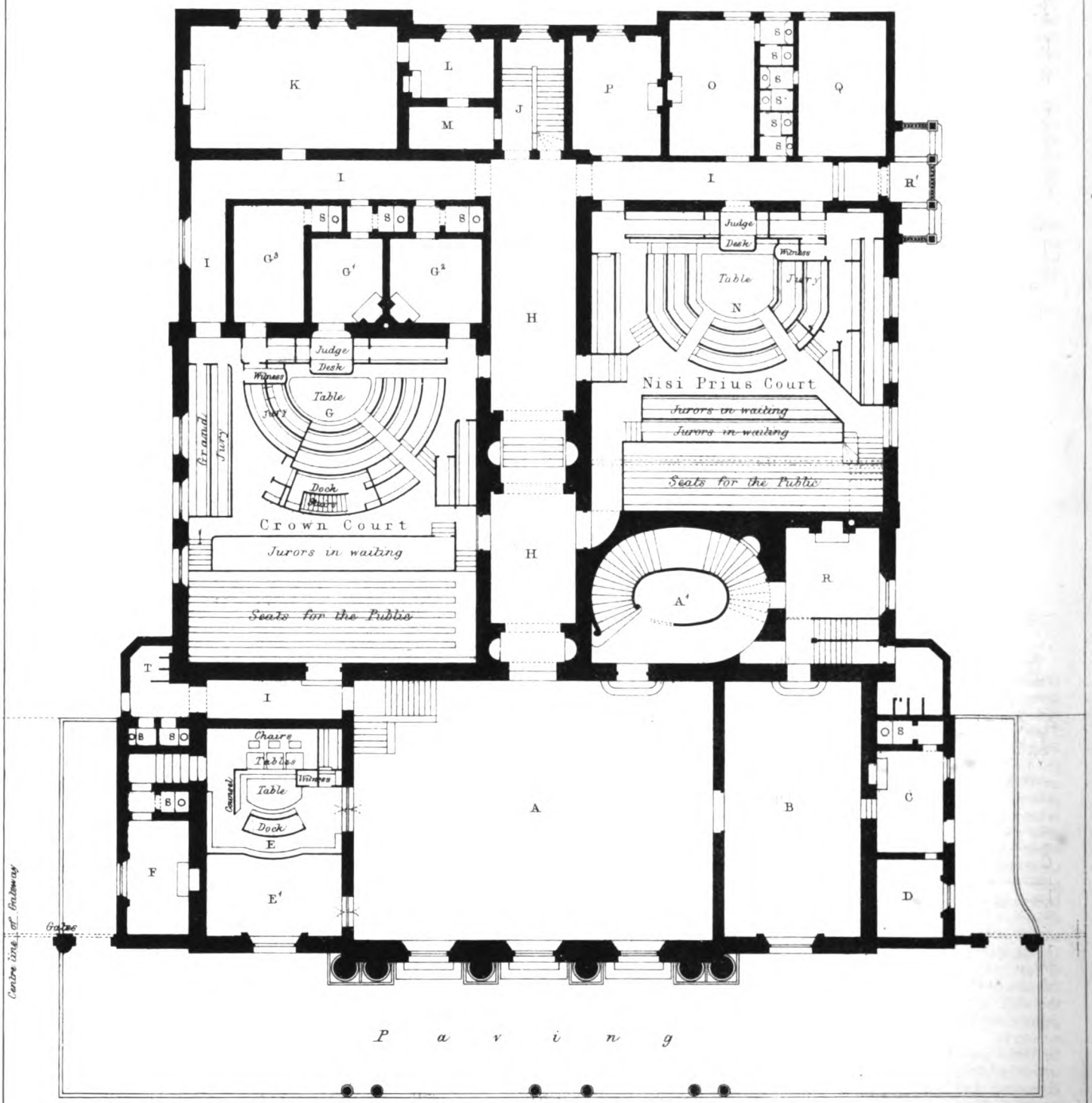
April 1859 J.R.Jobbins.

THE TOWN HALL AND LAW COURTS, ST MARY STREET, CARDIFF.

HORACE JONES, ARCHT

Digitized by Google

Digitized by Google



THE TOWN HALL AND LAW COURTS, ST MARY STREET, CARDIFF.

10 5 0 10 20 30 40 50 60 70 80 FEET

Digitized by Google

April 1859

J.R.Johnins

CARDIFF TOWN HALL AND LAW COURTS.

(With Engravings.)

THIS building is situate on the west side of St. Mary-street, Cardiff. It is of the Italian style of architecture, the front is Caen stone, the gate piers of Portland stone, the remainder of the work in rear and flanks is executed in Newbridge stone with cement dressings. The accommodation internally is as follows:—The entrance hall 50 by 37 feet, merchants' or reading room 36 by 19 feet, police court 36 by 19 feet. On the upper floor over these three rooms are the corporation room and ante room, respectively 70 by 36 feet, and 36 by 19 feet. The crown court is 45 by 40 feet, the nisi prius court 43 by 40 feet.

The acoustic arrangements of the courts are such as to have given general satisfaction. The ventilation is simple and natural, and without occasioning draughts. With reference to this particular, the courts have been favourably spoken of from the Bench, as well as by the general frequenters. A reference to the plan will give a clear idea of the general arrangements of the building, as well as of the minor accommodation.

The cost of the building was 12,500*l.*, exclusive of warming apparatus and gas fittings. The works were executed in three separate contracts, two of which were taken and carried out by Messrs. James and Price, and one by Messrs. Harris and David; all of Cardiff.

This edifice was designed by and executed under the superintendence of Mr. Horace Jones, architect, Furnival's-inn, London.

Reference to Ground Plan.

A. Entrance hall
A¹ Principal staircase.
B. Merchants' room or news room.
C. Court-keeper's room.
D. Bed room.
E. Police court.
E¹ Waiting room for public.
F. Magistrates' room.
G. Crown court.
G¹ Judge's room.
G² Barristers' room.
G³ Jury room.
H. Corridor.
I I I. Passages.
J. Lobby.
K. Grand jury room.
L. Grand jury retiring room
M. Ante room.
N. Nisi prius court.
O. Judges' room.
P. Barristers' room.
Q. Jury room.
R. Gentlemen's retiring room.
R¹ Judges' entrance.
S S S S. Water-closets.
T. Urinals.

THE ARCHITECTURAL UNION COMPANY'S NEW GALLERIES.

THE desideratum of a *locale* for the meetings of the principal architectural societies of London is at last accomplished, and we have the satisfaction of pointing to premises which, in their remodelled form, promise to be admirably suited to their purpose. They are situate (as most of our readers know) in Conduit-street, Regent-street, and were used previously as a dwelling-house by the Earl of Macclesfield. The frontage is not great, nor is there anything very distinctive in the external appearance, even under present circumstances, but there is a quiet substantial look, which is ten times better than unmeaning and expensive ornament. The area occupied by the several galleries is however by no means small, the principal rooms running behind and transversely to the Conduit-street building, while, in addition to these, there is a narrow strip, called the "north gallery," extending still further back, and communicating with Maddox-street. The plan may be described as follows:—approaching from Conduit-street we enter a spacious hall, at the end of which are the principal staircases. Descending a few steps we arrive at the large exhibition gallery, 60 feet long and 26 feet wide, beyond which, in continuation to the left, is the west gallery, 38 feet by 23 feet, and to the right is the east gallery, 50 feet long by 19 ft. 6 in. wide. The north gallery, before mentioned, is attached to the principal room, and measures 45 feet by 12 ft. 3 in. In adapting these apartments for their intended purpose it is evident that no pains have been spared, and we are happy in congratulating the architects, Messrs. Edmeston and Gray, on the successful termination of their labours. In the all-important matter of *lighting*, the favourable results we augured on our previous survey have been fully realised; it is everything that could be desired, both by exhibitors and visitors, which is saying a great deal. The proportions of the galleries are also well-disposed, and the ceilings effective, though as yet comparatively plain. In the principal rooms the ceiling is strictly elliptical—it would perhaps have been better a little *stilted*, as the line is partially hidden by the projection of the wall cornice—the transverse axis being rather more than a third of the conjugate (or span). Enriched ribs following this form divide the length into seven compartments, which are again subdivided longitudinally into corresponding panels, which are ultimately, we understand, to be decorated in colour. The light is wholly admitted from above, in a long narrow strip on each side of the constructive ridge of the roof, and immediately below it; the space between this glazed roof and the elliptical curved ribs being filled in with perforated scroll work in iron, very tastefully executed by Messrs. Hart and Son, and a like running enrichment separates the upper junction of the glazing, serving also for the purpose of ventilation. The principal and the west galleries are each 14 feet high to the springing of the ellipse; the east gallery measures 19 feet to the ceiling, and the north 12 feet. A committee-room, 20 feet square, and conveniently planned, completes the list of apartments on this floor.

This suite of galleries was opened for the Architectural Exhibition on the 15th ult., and will be occupied by the same till the end of June. From the middle of July till December there will also be a special exhibition of building materials, patents, and inventions; and from December till March the exhibition of the Architectural Photographic Association will be held here. The west gallery is engaged from the present time on the Friday evenings for the meetings of the Architectural Association, who are removing from Lyon's-inn hall, and it is also available on one evening each week for meetings of other societies.

Re-ascending the steps into the hall, we come immediately to the upper flight,—also of stone, and spaciously wide,—leading to the first-floor rooms; these are wholly devoted to the use of the Royal Institute of British Architects. The principal or lecture-room is 17 feet high, measuring 37 ft. 6 in. from east to west, and a foot less in the other direction. Its north wall is entirely new, and on this side is obtained nearly all the light for the room through a series of windows in a handsome arcade below the cornice. The general aspect is at present rather bare, owing to the poverty of the architectural adornments, and in particular of the ceiling and cornice, the style of which date perhaps about a century back. Something will probably be done by way of improvement. South of this room, and lighted by the first-floor windows of the Conduit-street front, are the libraries, measuring together 37 ft. 6 in. long, by 19 ft. 6 in. wide; while at the other extremity of the lecture-room is one appropriated for the council meetings, and measuring 24 ft. 6 in. by 20 ft. A second flight of stairs, also two or three small but convenient rooms, complete the general arrangements. The floor above it is intended to let as chambers or offices, while the third will be occupied by messengers and other officials of the establishment.

The alterations have been carried out by Messrs. Hack & Sons, of Poplar; the metal-work (as before mentioned) is by Messrs. Hart & Sons, of Wych-street; the heating—by hot-water pipes laid under an open grating in the floors—by Mr. Potter, of South Molton-street; the plastering by Mr. Parsons; the gas-fittings, which are simple but tasteful, by Messrs. Johnston, of Holborn; and the hall and approaches by Messrs. Minton, Hollins & Co., Messrs. Maw & Co., and the Poole Company respectively. There are also specimens of embossed glass from the establishment of Messrs. Rees and Baker, of Hatton-garden, introduced into some of the windows; while Moore's patent ventilators are fixed in the principal room of the Institute.

THE ARCHITECTURAL EXHIBITION.

ALL well-wishers to this exhibition will rejoice that it has at length taken such a position as to enable it to occupy galleries of its own, built for the purpose, suitable and commodious, and that thus it can be open annually, in the London "season," for the space of three successive months,—advantages which have long been a desideratum, and which will prove, if we mistake not, of signal service in furthering the interests, not only of our own profession, but those of the art-world at large. The fact, too, that His Royal Highness the Prince Consort has been pleased to allow his name to be added as patron of the exhibition, is a proof of the hold it has taken among influential circles, and may be accepted as an omen of still greater success.

Though compared with the previous exhibition the number of drawings this year is somewhat fewer, the apparent loss is

Digitized by Google

more than compensated by the improved facilities of lighting and hanging, which are at once evident on entering the new galleries. Yet that in the latter particular there is room for further improvement is manifest as we follow the pictures, catalogue in hand. Making every allowance for the pleasure which the eye derives from seeing an ingeniously-packed series of frames, containing an agreeable interchange in the pictures they enshrine of light and shade, colour and outline, this should not be indulged at the expense of that integrity of purpose and beneficial influence which an architectural exhibition ought to realise. One of the great features of a periodical display such as this, should be the careful arrangement of its subjects. It may be well supposed that each successive season will bring its quota from the competitive and other sources which have interested the professional world during the year. These it should be the especial endeavour of the committee in the first place to procure from their authors, and next to show their appreciation of the loan by so disposing of them as that they shall be readily examined, each with each. The services which might thus be rendered both to the practitioners of our art and their clients, are more than may at first be supposed, but as we have on a former occasion pointed out these more at length, we shall not go over the ground here. It must, however, be acknowledged, that the past year-and-half have not called forth so many productions of this kind as usual, and hence, probably, their comparative rarity on the exhibition walls. The great Public Offices Competition yet presents a solitary reminder or two, and we are glad to perceive among these the drawings prepared by Mr. Pennethorne, independently of, and previously to, the competition itself, and which have occasioned so much discussion. Of these we shall speak more at length presently.

The Lille Cathedral affair appears to have altogether subsided, the same with the Constantinople,—and Crimean memorials are giving place to others; the designs for the Ellesmere Monument, by-the-bye, here present a formidable array. A few also for Mr. Spurgeon's chapel, for the Chelsea Vestry-hall, for the Free Church, Edinburgh, for Heigham and Tottenham churches, and others, will be found also; but they are, for the most part, too scattered about to be practically valuable for comparative reference. To take an illustration. Almost the first number in the catalogue introduces us to an interior view of the successful design for the Folkestone Town-hall (lately decided); this is however too small and sketchy a drawing to convey much real information, and we are consequently but little enlightened on the subject, till we come to (150), where we find, misplaced, the corresponding exterior view. A little foresight and classification would surely have prevented this!

If the exhibition, taken as a whole, may not be characterised as a decided advance upon its antecedents, it is unquestionably up to the average standard, and can boast of not a few peculiarly interesting and valuable contributions. That important key to perspective views—a little block-plan in the corner of the frame —may now not unfrequently be discerned; these answer every ordinary purpose, while those to a larger scale are not so readily comprehended in general, and therefore not so explicit, besides taking up so much more room. Though there are not so many *outré* productions on the walls as we have sometimes seen, the number of designs existing as yet in imagination only appears decidedly to predominate over works executed or in progress; but while each of these is highly useful in its way, there can be no question as to which is of the greater practical service, and therefore have the preference of selection, if there be a choice.

The collection opens with a series of "Sketches made in France and Italy," by Mr. Nesfield, who in (31, 32) continues the same subject. These sketches are well chosen, and carefully as well as artistically handled. The plan of thus arranging kindred subjects is a useful one, and there are several other contributions of a like nature in the present exhibition.

(2) Illustrates the decoration of a portion of the roof of the Duomo at Monreale, near Palermo, Sicily, and embraces also a plan and section of part of the building itself. Like the majority of the ancient buildings in this island, this appears to possess considerable merit.

In (3), the same delineator, Mr. Lightly, presents a capital drawing of the Ambo, or pulpit, in the church at Ravello, with details of the mosaics. The elaboration bestowed on the latter is something marvellous, as travellers well know, and the whole is here minutely delineated. With regard to the coloured decorations, the patterns do not strike us as by any means equal to many we have seen in that country; red, blue, and white are the prevailing colours, mostly employed in stripes, and in the picking out of the geometrical forms which constitute generally the surface ornament. An ingenious kind of guilloche, and some interlacing borders, are deserving of examination.

(4). Mr. Dawson's, Photographs of a villa at Reigate are not altogether satisfactory. The architecture is of the mixed kind, partaking both of the Elizabethan and French-château character, —a combination which seldom works in happily.

(5). Design, by Ward and Hughes, for a seven-light window at Glenalmond College, Perth, is of the Flowing Decorated period, founded apparently on some well-known examples. The leading lines are not particularly graceful.

A slight sketch of the interior of Folkestone New Town-hall, by Mr. Messenger (6), shows a very plain-looking apartment, of Italian character, with an elliptical ceiling divided into bays by broad bands. In another room is the corresponding exterior view.

(7) Is a choice impression of the lithograph of Mr. Scott's "Dockyard Chapel, Woolwich," which appeared in the February number of our *Journal*, and which we have already described.

(8) Is a Mural Monument, designed by Mr. Truefitt, which, like all that gentleman's productions, bears the stamp of clever originality. The design before us does not however commend itself to us as one of his happiest efforts, notwithstanding that sculpture and inlay-work are introduced in addition to architectural forms.

(10), By Mr. T. H. Watson, may very well answer its purpose as an "Artist's Studio," but has no pretensions whatever to architectural distinction.

(11) Is one of the numerous drawings which exhibit "alterations" to mansions. In the present case these appear to be of an extensive character, especially in the outbuildings. The effect is more attributable to grouping and outline than to ornamental detail.

(12) Is one of several contributions by Messrs. Walton and Robson, being a free pen-and-ink sketch of the "Schools and master's residence now erecting at Redcar." In this, as well as in some other works exhibited by the same authors, architectural embellishment is almost wholly avoided; effect being sought by means of good general proportions and picturesque outlines, presenting a variety of groupings from different points of view.

(13) Is a valuable and elaborately drawn elevation of the west elevation of Winchester Cathedral, now undergoing restoration at the hands of Mr. J. Colson, of that city.

(14), (99), and a few more pictures, have their origin in dreamland. It may be entertaining, but surely is not very profitable, to indulge in such pleasures of the imagination.

Mr. T. W. Knightly's pretty vignette sketches (15), though most minutely rendered, are not sufficiently defined to investigate their architectural merits. The frame includes seven subjects, consisting of chapels, schools, and houses, "now in course of erection," in the Italian and Gothic styles. In 3 and 5 the round forms occur in the plan with good effect.

(16)—A selection from the illustrations accompanying the *Dictionary of Architecture*, now being issued,—makes a very interesting sheet. Among them will be observed the elaborate ceiling of Bishop West's Chapel, at Ely, also sketches of San Zenone, at Verona, and Amalfi Cathedral, which have been particularly well reproduced by Mr. Bedford. We learn that the Dictionary is now only about one-third finished, so that, at the rate at which it drags its slow length along, years must elapse ere the undertaking is fully accomplished.

(17). "Design for the church of SS. Peter and Paul, Berne; to which a gold medal was awarded" (G. Goldie). This is really so unsatisfactory a design, taken as a whole, that one is at a loss to perceive its peculiar charm in the eyes of the judges. The author appears to have culled from his foreign sketch-book a few choice details, and strung them together, regardless of general symmetry and harmony.

A brown ink-drawing by W. Smith (18), shows the nave arches (Norman) of Walsoken Church, Norfolk, and also the curious ancient seating, of Perpendicular date, and so elaborately adorned with figures in niches, buttresses, and complicated mouldings. Some additional seats have been introduced, to complete the restoration, but we are under the impression that these are by no means equally rich with the old ones: the details have possibly been tampered with to suit economical funds.

Mr. Tucker's "Villa residence, New Zealand" (19), does not

Digitized by Google

deserve the room it takes up; it is hung moreover in a place where its architectural barrenness is, by contrast, eminently conspicuous.

We own to an aversion to those emanations in which a vast amount of detail is crammed into a given space, without any specific object, except to gratify the fancy of the author by seeing his ideas upon paper dignified by the appellation of "a design." There are a few of this class in the present exhibition, but the one which comes under the title of a "study of a Palace Façade" (20), by Mr. Horton, is really a meritorious work, and nicely drawn: the style is Palladian, well composed, and the proportioning of the whole exceedingly good.

Mr. Ellis's proposed Bank, at Norwich (21), is Italian, and has a good substantial look, but otherwise is not very noticeable. The upper stories are in red brick with rusticated dressings in freestone (or cement?) The ground-floor is rusticated throughout.

(22), Barwick-house, near Yeovil, is Jacobœan of the worst kind. It is a pity that Mr. Shout should have perpetuated such abominations in remodelling this mansion, even if the old part were in this "pestilent" taste.

In (23)—Decorations for the Princess' Theatre, and for the Surrey Gardens Music-hall,—Mr. Kuckuck gives the reins to imagination in combining the real and the fanciful with something beyond artistic license. The result therefore will not bear scrutiny, but the colouring *per se* is judicious, and in the blending and diversifying of the hues there is nothing to complain of.

(24). Mr. I'Anson's buildings are among the best of their kind, and have contributed much toward "London improvements." In the drawing before us is a series of these, including the Fenchurch-street Chambers, and the Corn Exchange Chambers, Seething-lane: but they are represented on too small a scale to convey more than a general impression.

Mr. Roger Smith, in the "Independent Chapel and Schools" now erecting at Highgate (25), does not rise even to mediocrity in his Gothic notions.

Brickendon Grange, Hertfordshire (26), G. F. Jones, is a curious amalgamation of Gothic, Italian, and Elizabethan; the structure is apparently mostly in red brick, and the outline is picturesquely broken.

The "Warehouses recently erected in Montague-close, Southwark" (27), T. C. Clark, are among the best and most characteristic we have seen. There is no attempt at extravagant display or inappropriate features: all is simple and truthful, and therefore satisfactory. A slight relief in colour is gained by the use of red brick in the arches, &c.

The next drawing (28) is a sort of burlesque on a most interesting ancient subject—Holy Cross Abbey,—and should unquestionably have been rejected.

(29). "Stephenson Memorial Schools, Willington, near Newcastle-on-Tyne," are erected on the site of the cottage where he once lived, and are very fair specimens of Gothic, though perhaps rather too ambitious. The materials are red brick with white dressings.

In (30), Mr. R. H. Shout exhibits a good architectural drawing, of the genuine kind. It shows the "Schoolhouse now erecting at Abbotsbury, Dorsetshire." There is some originality in the design, although marred by the disproportionate size of the windows.

(33). "New Printing Offices, Bread-street-hill," by Mr. Dawson, are built of yellow malms and red bricks with stone weatherings; while extensive portions of the building in the rear are constructed in cast-iron. The design itself is very poor.

(34) Is an enlarged view of the Seething-lane Chambers, which we have before mentioned (see No. 24). The drawing does not do justice to the subject, it being, like the colouring, far too heavy and laboured.

The "Roman Catholic Church now erecting at Bandon" (35), is designed in better keeping than some others of Messrs. Hadfield and Goldie's works, but it is not free from mannerism. The apsidal end tells well in the grouping, but the best effect is acquired in the belfry stage, and the short spire by which it is surmounted.

(36) Presents "Christian Memorials" in a variety of forms, but nothing new. They consist of crosses, altar-tombs, headstones, and brasses, tastefully selected, and neatly drawn.

Mr. Clayton's "Station at Tynan, on the Ulster Railway" (37) is nothing short of being absolutely ugly; but that at Glasslough, on the same line, is a happier conception. Some timber construction is well devised, also the bell turret.

(39), A "Design for a Façade," may be supposed to be in the Louis Quatorze style, and will exist, we hope, only on paper.

Twelve large coloured views, explaining Mr. Owen Jones' design for the "Palace of the People," Muswell-hill, form a very handsome termination to the end wall of the gallery. As we have, in a previous Number, called attention to the leading features of this vast project, and described its architectural contrivances, it will be sufficient to say, that, by the fortunate acquisition of these drawings for the exhibition, every facility is afforded for a thorough acquaintance with the attractions presented by this noble scheme.

Mr. J. W. Papworth's "Albert Institution, Blackfriars-road" (50, 51), is utterly tasteless in point of design. It is exhibited under two different arrangements, the second having the addition of an upper story. This is the better-looking front of the two.

The only contribution by Mr. St. Aubyn is a small lithograph (52), of the Church at Kilmaloada, Ireland, which seems to possess, like that gentleman's works in general, some happily designed though unobtrusive features.

The Branch Banks at East and West Hartlepool, by Messrs. Pritchett and Son (53, 54), are very tame-looking; indeed, scarcely beyond ordinary street buildings.

Binstead Church, is a well-known early specimen of architecture, one of the few of that date tolerably perfect in the Isle of Wight. Mr. Hellyer's interior view (55) shows the building itself intact, but the whole polychromed to an intense degree. For all this there is doubtless the authority of precedent, but it is a question how far it is advisable so fully to mask all architectural features as to inevitably disguise their real details.

(56) Is one of the cleverest pictures in the rooms, whether we look at the pleasing novelty of the ideas, or the telling power with which they are expressed. Imbued with continental ideas, Mr. Blomfield has managed to engraft some tasteful notions on what might be deemed a very common-place subject—Drinking Fountains. The combinations of stone and metal are effectively brought to bear, and have evidently been well considered.

Placed wilfully in contrast, one might almost be led to suppose, is Messrs. Driver and Webber's "Memorial Fountain" (57),—a specimen of pseudo-Gothic about as much below the average as those we have just quitted are above.

In (59) we have an elaborate pencil drawing, by Mr. T. Vaughan, of the South Transept and Tower of York Minster, while in (92) the same artist treats us to the Towers of Lincoln,—in (119) to sundry other bits from York,—in (140) to a "classical" subject, a "Design for a Circus," which gained the Soane Medallion of the Institute of British Architects in February last;—in (142) we return to "Gothic," in the shape of a vista down the South-east Transept of Beverley Minster;—in (345) to a view of the Western Towers of Durham;—and, in (346), to a final peep into the Presbytery at Lincoln Cathedral. This collection supplies, in itself, almost enough data for tracing the successive phases of mediæval architecture, and though not rendered with a particularly free touch, are so carefully detailed as to make them highly serviceable for comparative study.

Want of space forbids us to pursue our examination further this month, but in the next Number we purpose resuming this subject; and we shall finally devote considerable attention to that important feature of the exhibition,—the "Department of Materials, Inventions, and Manufactures."

Several interesting lectures connected with art are announced to be delivered on successive Tuesday evenings; and to-night the Architectural Association holds an inaugural *conversazione*, when the whole of the rooms will be thrown open to the visitors.

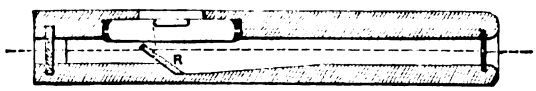
ROYAL SCOTTISH SOCIETY OF ARTS.

At the meeting of this society held at Edinburgh on the 14th February, the vice-president, Mr. R. H. Bow, C.E., read a Paper on "*Several forms of Spirit Levels that may be used without tripod or other fixed stands.*" The principle on which Mr. Bow's levels are planned consists in such an arrangement that the observer may note at the same instant the height of the cross-hair as projected against the levelling staff, and the momentary central position of the bubble in the spirit-level. The simplest form of the instrument, shown by fig. 1, differs but little in external appearance from the common pocket or workman's spirit-level, and can be put to the same uses in addition to its particular duty of affording observations by being simply held in the hand while

Digitized by Google

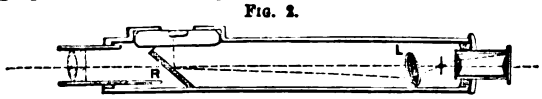
looking through it. For more accurate observations various forms of the instrument were exhibited, in which a telescope with cross-

Fig. 1.



hairs was incorporated with the spirit-level: the most perfect of these is that shown by fig. 2, in which by means of the very narrow reflector R, and the thin slice of a lens L, an image of the bubble is formed near the cross hairs, and consequently seen as though part of the landscape.

Fig. 2.



Mr. Bow explained at considerable length the beautiful principles employed in the construction of Prof. Piazzi Smyth's "Spontaneous horizon points," and summed up with remarks upon the merits and defects of levels to be used without fixed supports, or at sea, showing that though they could not be depended upon for very accurate work, they yet deserved to be considered instruments of considerable practical importance, from the expedition with which results could be obtained by them, and the valuable aid they could afford to the exploring traveller, or to the engineer in search of the best general route for a road, railway, or canal. For the latter purpose the simpler form of the instrument may be made still more complete by having a series or scale of cross-hairs, so that the general gradient of a plane or valley may at once be perceived.

GREVILLE PLACE CHURCH, EDGEWARE ROAD, KILBURN.

(With an Engraving.)

The church in Greville-place, Edgeware-road, now in course of erection, is being constructed of brickwork, the walls being faced with yellow malm bricks, in which many elaborate patterns of red and purple Staffordshire bricks are worked. Great relief and boldness are given to the arches by the introduction of ornamental designs in the brickwork, as indicated on the elevations. Most of the arches are gauged. In the interior the whole of the arches and uprights are of wood, resting on cast-iron twisted columns. The spandrels of the arches are filled in with tracery, pierced only. The clerestory is of cast-iron, fitted into the woodwork.

The vestry communicates with the church, but can be screened off for evening services when required: the large arch is for the reception of an organ. The spire is of stone. The contract for the erection of the church (including the spire, but exclusive of seats) has been taken by Mr. Simpson, builder, of Goodge-street, for the sum of 1711*l.* 16*s.* 2*d.*

The church is designed to accommodate 416 persons on the ground plan, and 146 in the gallery, making a total of 592 persons.

The architect is Mr. Edward Habershon, of 37, Bedford-place, Russell-square, London.

FLOATING DOCK GATE, DUNDEE HARBOUR.

Designed by Mr. Ower, C.E.

The Engineer to the Dundee Harbour Board, Mr. Charles Ower, who is superintending the extensive new works now in progress at the harbour, in order to meet certain local requirements, has invented a floating dock-gate of very skilful construction, opening and shutting in a novel manner, and capable of answering as a bridge both for foot-passengers and carriages. The opinion of Mr. Fairbairn upon the subject was invited, and that gentleman's report, recently made to the Trustees, which we append, is highly satisfactory.

"Manchester, Jan. 10, 1859.

"Gentlemen,—Mr. Ower having submitted to me a model and drawings of a revolving floating gate, proposed to be erected for closing the entrance into the Victoria Dock, I have, in compliance with the resolution of your board, given the subject my best consideration. The structure, as shown on the drawings, is composed entirely of iron, and so constructed with interior cells or floors as to enable the gate to float a few inches above the bottom, when it may be opened and closed with facility and despatch. To effect these objects, and in order to afford the necessary powers of resistance to the pressure of the water during all states of tide, it will be necessary to make certain modifications in the construction. This is the more essential as the gate should open with the same facility at the lowest neap as at the highest spring tides. To meet all these requirements, and at the same time to make it answer as a bridge of communication between each side of the dock, I would recommend as follows:—

"1st. That the caisson or floating gate be made of the rectangular form, 64 feet long, 10 feet wide, and 29 feet deep, and to be composed of plates varying in thickness from eight-sixteenths to five-sixteenths, according to position.

"2nd. That the weight of the gate will be about 150 tons, equivalent to its displacement at a depth of 8 feet; or, in other words, it will rest upon the bottom of the dock with a pressure at low water of about 2 tons at neap tides.

"3rd. As the gate is not intended to be opened but at high water, it will require about 200 tons of ballast, either of water or ashlar stone, in the bottom, to prevent floatage until the height of neap tide or 10 feet from low-water mark is attained. In this position I would recommend, in addition, that up to the highest spring tides the floatage of the gate be regulated by sluices, to admit the water from the dock into the water chamber below, and *vice versâ*, to run it out again at low water when the gate is sunk in its place. In addition to these arrangements I would recommend, in order to give increased facility for regulating the floatage, that the upper division be formed into a water tank for sinking or raising, under any circumstances that may occur in the opening or shutting of the gate.

"By this arrangement it will be seen that the rollers shown on Mr. Ower's drawings may be entirely dispensed with, as by the discharge of a small quantity of water from the proposed tank the gate may be floated, if required, at an earlier period than high water at neap tides.

"As regards the strength of the gate, I calculate its powers of resistance, at 10 feet wide, to be 3560 tons equally distributed over the surface; and the greatest pressure that it can ever be subjected to will be about 600 tons, thus giving a ratio of strength nearly as 6 to 1. Looking at this large margin of strength which we have in a gate thus constructed, I would recommend that the breadth of 11 feet, as shown by Mr. Ower, be reduced to 10 feet, which will be quite sufficient for that purpose, and that the roadway be formed with T iron covered with 3-inch red pine, as shown in the annexed sketch. Under these circumstances, only one water-tight floor will be required; the others may be formed of open work for the purpose of stiffening the sides of the gate. In this construction I would further recommend that Mr. Ower's circular plates be dispensed with, and in lieu of them, plates, 2 feet wide, and varying from three-eighths to five-sixteenths, be rivetted to the floor, beams, or angle irons. This would prevent flexure, and give increased rigidity and strength to both sides of the gate.

"Having thus discussed the mode of working, strength, and other proportions of this new method of closing and opening the entrance into docks, I may shortly advert to the old plan of gates usually adopted for this purpose. In these it will be seen that much time is lost in opening and shutting; and a much greater number of men is required than is necessary in the present case, where the whole can be done from one side, thus affording increased facility in working vessels in and out of the dock.

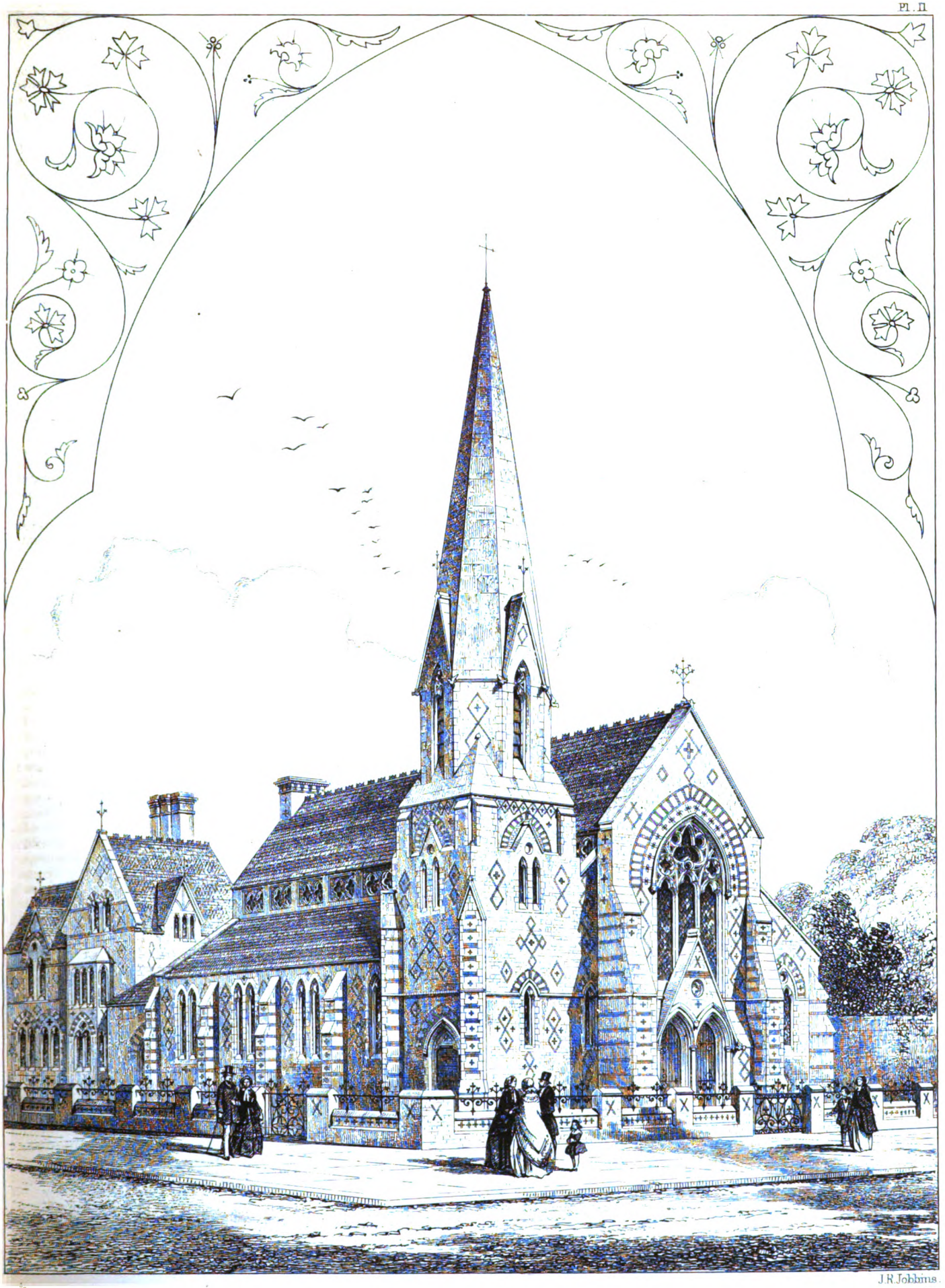
"In the sliding caisson which I constructed for the Government steam docks at Keyham, Devonport, it can be opened and shut in eight minutes, and that simply by floating it into a recess instead of causing it to revolve on a centre as proposed by Mr. Ower, which, I think, in your case is an improvement. Again, this construction answers the double purpose of a bridge as well as that of closing the entrance into the docks, and thus saving the expense of a separate structure, and all the cost of attendance to open and shut the bridge at the same time the docks are opened.

"I have, &c.,

"Wm. Fairbairn."

Mr. Ower's floating dock-gate is now in course of construction, and as soon as completed we propose returning to the subject.

Digitized by Google



J.R.Jobbins.

Greville Place Church, Edgeware Road, London.

EDW^D HABERSHON, ARCHT.

Digitized by Google

Digitized by Google

ON METROPOLITAN IMPROVEMENTS AS AFFECTED BY THE BILLS NOW BEFORE PARLIAMENT.*

By T. M. Rickman.

One of the most systematic examinations of the principles of metropolitan improvements was conducted by the Metropolis Improvement Commission, which made its first report in 1844. Two sentences from the opening pages are of great importance. Respecting the plans submitted it is said: "The utmost attention will be required in selecting such of them as may appear to possess the highest claims, and at the same time to be within the limits of practical and not too expensive execution." The other refers to Sir Christopher Wren's proposed recast of the metropolis: "His attempts were thwarted by public bodies and individual interests;" and it is added, the consequences of the Fire of London as regarded the disposition of the city were but to accelerate the westward movement of the nobility.....The extension of the town is the work of private enterprise, but the openings of internal communication must be effected by public aid."

For a long time improvements to a small extent in the city had been conducted by the corporation. The necessity for a bridge at Westminster was considered local, and not metropolitan. It was completed in 1750, with funds partly raised by a lottery. About 1795 the same means were adopted for throwing open Snow-hill and the site west of Temple-bar. Blackfriars-bridge, or "Pitt's bridge," finished in 1769, was paid for by a toll, continued for a number of years. Waterloo, originally "Strand" bridge, was erected by a private company, and opened in 1817: Southwark-bridge by similar means in 1819; in connection with it was the opening of King and Queen streets. Hungerford-bridge was opened in 1845. The great improvements at the west-end were carried out at the ultimate expense, in great part, of the land revenues of the crown, with a large aid from the consolidated fund. London-bridge was opened in 1831, and the present coal tax assisted in a great measure in the completion of the approaches. The tax has since been expended in the formation of other streets, and has hitherto been considered the sole pecuniary means of effecting "metropolitan improvements." The City Corporation Commission, which aided in the introduction of the Metropolitan Management Act, reported against that tax, and in favour of one to be levied on the whole metropolitan district for the purpose of improvements. The coal tax lasts till 1862: it is entirely hypothecated. Till other funds are forthcoming, or the new tax established no extensive improvements can be carried out.

In the year 1813 the "Commissioners of Woods, Forests, and Land Revenues of the Crown" made their first triennial report after their connection with the "Board of Works," on the state of the property confided to them, with a statement of their proceedings. One of the first points to which their attention had been directed was the improvement of the Marylebone Park Farm. The offer of a premium of £1000 not having produced any design calculated to effect the desired result, Messrs. Leverton and Chawner, surveyors to the Office of Woods, and Mr. Nash, one of the architects to the Board of Works, were requested to furnish plans. The former sent in a design for laying out the larger part for building purposes; the latter one, which gave a much more extensive area to the public, and combined the erection of terraces, villas, markets, and streets on the eastern side, with a new street to Pall-mall in a line with Portland-place. This, or Regent street, as at first planned, terminated in a square inclosing a public building. This arrangement, principally from want of means, was changed into the present Quadrant, after the execution of the main sewer, which consequently in some places runs under the houses. Regent-street was opened in 1819. The total cost in 1826 was £1,315,000, of which £515,000 was paid from the crown revenues, and £800,000 from the consolidated fund. The annual income was £36,000, but ultimately it will be £160,000. The net cost of laying out the Regent's-park, which was defrayed out of the crown revenue, was stated in 1823 to be £20,000.

This great artery having been opened, and the lung formed—the Regent's-park—the commissioners proceeded in their labours eastward. Mr. Nash's plans for continuing Pall-mall to St. Martin's-lane gradually grew into the formation of Trafalgar-square, and the buildings on its east, north, and west sides, with the district between the Strand, Agar-street, and the south side of Chandos-street. Some progress was made in the continuation of Pall-mall in 1823: and shortly afterwards the growing attraction of the British Museum was adduced as a reason for widening St. Martin's-lane; but this improvement was only carried out as far as the corner of Chandos-street. The report of 1826 describes the passing of an act to widen the Strand, the new works in connection with the Charing-cross improvements having rendered the northern side of that thoroughfare an eyesore. An act passed in 1826 (the Charing-cross Act) included powers for improvements in Downing-street and King-street, Westminster. In 1835 the whole of the purchases had been completed, the land revenue having paid the cost (which was ultimately £1,196,000), except £600,000 still due to the consolidated fund. Of the above sum £1,058,000 may be set down to the improvements at Charing-cross.

Two results ensued from the lavish expenditure on these great works. It was desired to extend the improvements, but it was not thought fit to continue the unlimited system of borrowing from the consolidated fund to supply the land revenues of the crown. The widening of the lower part of St. Martin's-lane, with the view of opening up a communication from Charing-cross northwards, pointed to Long-acre as an intermediate westerly route, and its continuation westward through Leicester-square to Piccadilly was seen to be of importance. The opening of Waterloo-bridge in 1817 pointed out the improvement of Bow-street, and the formation of Endell-street. The straightening of the Oxford-street and Holborn route, by cutting New Oxford-street, seemed most desirable to improve the northern east-west route; and the opening of Bloomsbury-street to connect Endell-street with St. Martin's-lane, and the clearing away the middle row and projecting buildings at the head of St. Andrew-street in Broad-street, St. Giles's, followed as the result; and while so much was proposed to improve the east-west routes on the Middlesex side, it seemed but proper that a new parallel route on the Surrey side should be projected to connect Westminster-bridge with Southwark. Mr. Nash had prepared plans for Cranbourne-street and New Oxford-street, but the state of the crown revenues, in consequence of other large operations, prevented any works of importance in this direction from being carried out for some years, except those connected with Wellington-street and Bow-street, which were effected to a great extent by arrangements with the adjoining owners; but in 1839 the commissioners reported that all the new streets authorised by parliament had been completed, and the debts paid; that the growing produce of the crown estates would be paid to the Ways and Means, and the produce of sales invested.

In 1836 and 1838 committees of the House of Commons were engaged in examining the plans which had been brought forward, and in ascertaining the funds available, and the expense likely to be incurred. The last committee reported in favour of three routes: (1) Cranbourne-street and Endell-street; (2) New Oxford-street; (3) Spitalfields;—consequently in 1839 an act was passed authorising the construction of these streets, and granting for that purpose a charge upon the London-bridge Approaches Fund of £200,000. In the following year, the commissioners finding the amount voted far too small, came to parliament, and requested either to be restricted to one of the plans, or to be allowed more money; and in conformity with the recommendations of the select committee of 1840 on this subject, an act of the same session was passed continuing the coal tax for four more years for this purpose. In 1844 Cranbourne-street, and in 1845 New Oxford-street, Endell-street, and the new street in Spitalfields were opened, at a total expense of £841,000, though on a reduced scale.

In 1842 a commission was appointed to inquire into the most effectual means of improving the metropolis. The first report appeared in January 1844, and others from time to time till 1851, when the seventh and last was issued. The completion of the Spitalfields line through Whitechapel to Christ Church, and the important vegetable market, had rendered it still more desirable to continue the line of street to the Eastern Counties station and on to the City-road. An act was therefore passed in 1846 enabling the Commissioners of Woods to complete the first portion of the work. The funds were to be supplied from the penny duty on coals. This duty had been first levied to pay the expenses of the new Coal Act, the erection of the Coal Exchange, &c., but as those objects had been accomplished, and the execution of this work was pressing, its application to this purpose was guaranteed by the act of 1846, but it was not till 1849 that the commissioners

* Paper read at the Royal Institute of British Architects.

Digitized by Google

could raise money upon this duty to carry out their undertaking: the whole was formed by the Commissioners of Woods, with the aid of mortgages on the spare land, and the street was opened in 1858. The continuation to Old-street and City-road now lies with the Metropolitan Board of Works. In 1844 the opening of Albert-gate was completed, partly at the expense of the land revenues of the crown, and partly by arrangement with Mr. Thos. Cubitt. In 1851 the opening in front of Buckingham Palace, and the removal of the Marble Arch were effected; and from that time to the present the entrance to St. James's-park from the Victoria-road and Belgrave-place has been progressively enlarged.

Victoria-street, Westminster, was opened in 1852 with the aid of considerable grants from the coal duties, &c. The difficulties which the crown did not feel have fallen heavily on the Westminster Improvement Commissioners. The lessees who undertook Park-crescent failed, but the crown obtained others; whereas the Westminster Commissioners advanced heavily on the buildings in Victoria-street (it is said to the extent of £400,000). Their administration has been questioned, both as to the withholding of accounts, and the issue of bonds without security; and their affairs have become food for the lawyers. The creditors refused two years ago the bill proposed by the commissioners, and there are now two rival bills for effecting similar objects; one for authorising sales through the medium of the Court of Chancery, the other for a reconstruction of the commission on an equitable basis.

The construction of Victoria-park and Battersea-park illustrates another phase of public improvements. On the death of the Duke of York, the lease of the house which he had built, being heavily mortgaged, was bought by the crown. In 1827 it was sold to the Marquis of Stafford for £72,000, but as an assignment could not then be made the money was vested in trustees, and remained out at interest till 1841, when it amounted to £115,683. An act having been passed to enable the Commissioners of Woods and Forests to purchase and form the Victoria-park, this sum was applied to the purpose, and the remaining expense, about £14,000, was defrayed out of the revenues of the crown. The area purchased was 266 acres, of which 45 are retained as building land, and let by the crown. The purchase of Battersea-park was authorised by an act of parliament in 1846. The funds were to be advanced by the Exchequer Bill Loan Commissioners, to the extent of £200,000; it was calculated that this sum would be sufficient, and that the return from the building land purchased at the same time would eventually repay the whole cost. It was a good time for purchasing land in that district, but from the irregularity and long delay in the advance of the requisite funds, the land increased in value; and in 1853, when the purchases were completed, the cost, including formation and expenses, amounted to £316,000. The total area of land purchased was 319 acres, of which 125 are building ground. The whole of the park is made ground, the bed of the ornamental water being about the level of the original ground. Closely connected with Battersea-park is the erection of the new Chelsea-bridge. The design, like that of many of our bridges, has undergone numerous changes—wood, stone, iron, suspension. The act empowering the Commissioners of Woods, &c. to carry out the embankment of the river connected with this work dates 1846. The Improvement Commissioners made their sixth and last report in 1847, and devoted it to this subject. Great endeavours were made to effect the embankment by private arrangement; but up to the present time the conflicting interests of private individuals have succeeded in thwarting the extension beyond Chelsea College, and the powers of the act have expired. The bridge was long delayed through the failure of a contractor, but was opened in the spring of 1858.

The first subject on which the Improvement Commissioners reported was the embankment of the Thames. In 1844 they referred to the change which the river had undergone from the removal of Old London-bridge, authorised by an act of 1823, and to the irregular curves with the projections and recesses of the banks. An act of 1678 had regulated embankments for a long time; but, gradually falling into disuse, it was repealed in 1821. Messrs. Walker and Burges laid down certain lines, which have been theoretically the limits of projection; but they have been practically followed only to an insignificant extent, if at all. The authority in these matters now rests with the conservators of the river Thames. It was not thought till 1840 that the Thames had found the limits of alteration from the change in London-bridge. Since then many have been the schemes for utilising the banks of the river. Since 1824 Sir F. French had been ventilating this subject. In 1844 Mr. Walker, on behalf of the corporation, was pressing his scheme, but at that time insuperable obstacles prevented its execution. The two plans then considered the most feasible were Mr. Walker's for a broad embankment into the river, and Mr. Page's for a wall with a roadway, retaining in many places large tidal reservoirs up to the present banks. The first would require the wharves of each proprietor to be brought forward and changed, while it would reduce the mooring ground for coal barges, which is of continually increasing extent. Mr. Page's plan, while it filled up the frontage where no trade was carried on, left openings for the vessels and the tide at many points. The conclusion of the commission was in favour of an embankment for improving the navigation, while the importance of combining this object with the conveniences of additional land communication was considered great: the space to be thus treated most recommended by the commission extended from Westminster to Blackfriars, and for that purpose an increase of 5*d.* per ton on the coal duty was suggested. We have now the Metropolitan Management Act, the institution of the Metropolitan Board of Works, armed with a rating power, and the reconstitution of the conservators of the Thames,—measures following in conformity with the recommendations of the Corporation Commission of 1853-4. The abolition of the privileges of the Thames watermen and lightermen (not a city company proper, but dating from the time of Henry VIII.) also urged by the report, is now the subject of a smart agitation in the city.

The corporation have always been engaged in improving the city; for since the passing of the act after the great fire, which required a 40-feet way from the Temple to London-bridge, the streets have never been wide enough. New London-bridge and the Exchange have been connected by a series of fine open streets which have ramified. The Post Office and the Bank have been likewise centres for considerable openings under different authorities; but in both of these cases the plan has not been carried out on a scale sufficiently complete to afford all the advantages which might have accrued to the public. The uselessness of Gresham-street, and the difficulty of now improving it, are instances of the want of system from which the labours of the several authorities have sprung. The noble opening of Cannon-street, at the cost of £500,000, is also waiting for a more convenient access at the west end to accomplish the purposes for which it was designed. This street and the greater part of the last-mentioned improvements have been the work of the corporation, aided by the coal tax. The opening of the district round the Post Office was to a great extent a government affair, and with the administration of that day rests the charge of having put off the purchase of the property between that building and Cheapside, and of so placing the building itself as to prevent convenient access to St. Martin's-le-grand from the east. A valuable site for opening up this building is now being built upon. The improvements in opening Farringdon-street, forming the market, purchasing the site of the Fleet prison, and forming the Victoria-street, have been the result of disjointed action. The commissioners appointed to execute the latter were unable to complete their task with the means at their disposal, and it merged at last into the hands of the Corporation.

The improvements now authorised, for which sums have been provided, are: the communication between St. Martin's-lane and Covent-garden, for which purchases are being made; a short street exclusively in the Bedford estate, from Burleigh-street to Tavistock-street, aiming at the south-east angle of Covent-garden; the new street from Stamford-street to the Town-hall in the Borough; New Earl-street, to lead from Cannon-street to the west end of Upper Thames-street; and the approach from Limehouse, at the junction of the East India Dock-road and the Commercial-road to the south end of Grove road, and thence to Victoria-park. The rebuilding of Westminster-bridge, with the removal of the houses on the south side of Bridge-street, and the widening of Newgate-street, are gradually progressing.

Let us here take a cursory view of the requirements of London as our metropolis. Its position is on the main river of the country; upon a bend of that river, as in old times the military views of the founder dictated. The low grounds on the south side held the out-posts, the "tête du pont," Southwark. The Tower was adjacent to the walls of the city, at a short distance from the bridge. Away to the west the Isle of Thorney, with its monastery; opposite to it Lambeth. This concrete has become

Digitized by Google

one nucleus, and the London of the present day has arisen. Thus we have routes east and west as the main metropolitan thoroughfares. London is a town of commerce—a great depôt: commerce is conducted by shipping and by railways—hence the connection between the docks and the town and railways is of primary importance. The Thames is the great highway for London, and it bears its proportion of local traffic both for passengers and for articles of consumption. The docks require immediate connection with railways, especially for imports: they require for their export trade connection with the whole of London, by wide roads and easy gradients. All the railways therefore require to be linked together, and connected with the docks and river for their goods traffic, so as to avoid trans-shipment and unloading. Then as to passengers—the railway termini and the main streets must be laid out with reference to each other. In every metropolis there are two centres of interest and importance; one, the civic and commercial, where the local government has its seat among the marts of industry, the sources of its individual power and position; the other that of the government and of all connected with the throne, the aristocracy and the administration of the country. The original relative position of London and Westminster has been the key to the class division of the metropolis. Centered at Charing-cross are the streets of the west-end, and at the Bank those of the east-end; in the immediate neighbourhood of each of these centres the value of property is immense; between them lies a district of secondary value, and towards the extremes the value gradually diminishes. Property is valuable in these spots because vast masses of people engaged in their proper callings congregate there. Therefore, for the passenger traffic, the railways should have termini of great capacity as near these two centres as possible, while the less valuable ground in the intermediate district points out that locality as for occupation by the main arteries of the empire. Then these main stations, with abundance of minor stations and convenient loop-lines for the use of the outskirts, ought to put the passenger traffic of the metropolis on a sound and practicable footing. This is the end towards which the efforts of the railway companies now tend. The North London line, with the Blackwall and Greenwich lines, and the West London Railway, are links in the chain of loop-lines; the Eastern Counties find their account in adopting the Fenchurch-street terminus. The Thames separates the South Eastern lines from the city at present, and the London-bridge and Fenchurch-street stations must be considered as grouped together. The greatest efforts are now making on the part of the southern, western, and northern lines to obtain a station at Charing-cross, and if the Duke of Northumberland can be prevailed on to give up his mansion and grounds (not now what they were), the noblest site in Europe may be turned to proper use, and London no longer be beaten by Liverpool in the position of her central terminus. The Victoria station for Belgravia will group with the last mentioned centre. But neither the Bank nor Charing-cross can be reached by the Great Northern, North Western, or Great Western railways, except by long detours. Their interests are the same, their power of attracting passenger traffic greater than any others. The land lies vacant in Farringdon-street, or poorly built on in Moorfields, for their stations; and yet session after session passes without their securing a position, the key to the whole metropolis.

To return to the political distinction between the east and the west centres of London, between the city and the court, between commerce and legislature: as there is in reality a medium, so there should be in fact a locality devoted to their mutual action. The administration of justice and the law, while it gives the poor the advantages of the executive government, is the means of returning to the commercial classes great advantages, such as can only be purchased by the steadfast maintenance of the authority of government and by respect to the laws of the realm. The judges of the land are the representatives of the crown. The justice they mete is the test of the honour of the nation. The courts of law should therefore be so situated that the commerce and the executive legislature of the country should have equal access to its halls.

For improving the eastern central stations there are no propositions. The increase of traffic is proceeding; but the divided interest in the London-bridge railways has produced its effect in the great endeavour on the part of the South Eastern line to obtain a better footing at the west-end than its twin brother, the Brighton line, has already obtained through the West-end and Crystal Palace lines, leading into the Victoria station. The East Kent, or direct Dover line, has arranged to run into the Victoria station; and for that reason the South Eastern must come westwards to Charing-cross or elsewhere. There are several schemes for taking the South Eastern to the Victoria station, by southern loop lines; but the scheme which seems to promise most result is that called the London-bridge and Charing-cross Railway. This line starting from the north side of the London-bridge station, crosses over the stream of people at the south side of the bridge, bears south of St. Saviour's, and adopting nearly the line of the originally proposed new street, is connected with the Waterloo station, and crosses the Thames at Hungerford, using the market and adjuncts for its terminus. Any one of the lines proposed to connect the West London Railway with the South Western line would in effect give all the lines north-west and south-west of London opportunity of entering either at Charing-cross or the new Victoria station. Besides the last mentioned line, as affecting the West central stations, there is the South Metropolitan Railway proposing a high level line from the South Eastern, through the southern parts of Lambeth, across the South Western and the river to the side of Victoria-street, Westminster, where a new station was proposed. But the scheme has given way before others having more influential support. The Victoria station and Pimlico line are now constructing: these will give as good a station for Belgravia as the Great Western has for Tyburnia. Hence the schemes having for object the connection of this railway with the western lines by a line from Kensington, either through Chelsea or through Battersea. These western lines rest upon the West London Railway, "*Punch's* line," and each scheme for adapting this railway, and its possession the Kensington canal, also proposes to improve its connection with the Great Western and North Western lines, and to connect it with the Hampstead Junction line. So much for the eastern and western group of stations,—for Paddington station cannot be considered as fulfilling the conditions of a first-rate position. We come then to the central stations which should serve those lines that carry the passengers to the manufacturing districts of the North and Midland counties, to Scotland, and to Ireland. The Metropolitan Railway and Regent's Canal Railway are schemes for this purpose. The enormous traffic conducted at the Fenchurch-street station shows that good management will prevent any confusion; and the advantages to be derived from a station so accessible to business men from all parts of the town, as is the bottom of Holborn-hill, if the law courts settle down near Temple-bar, or as the neighbourhood of Finsbury for city men, especially for long journeys, in place of the present Euston, Paddington, and King's-cross stations, needs no argument; nor would the advantages be less perceptible for local traffic. The decision of this conflict will decide the position of the New Post-office.

Before leaving the railways one further scheme deserves attention, that of the Thames Embankment and Railway. It combines the points recommended in the report of the Improvement Commissioners in 1844, and though urged year after year, is still fighting its way; now with Walker's lines, now with the wharfingers and the hay barges, and in its railway department with the Victoria station and Pimlico, and the King's Scholars' Pond sewer.

In conclusion a few remarks on the various streets proposed to give passage to the traffic of the metropolis. Southwark-bridge requires a new Middlesex approach, and to be made toll free; New Earl-street requires to be continued till it reaches the embankment of the Thames and the "Quai de la Grande Bretagne," or else to be stopped by St. Paul's Bridge-road. The routes to the docks by Tower-hill and Commercial-street require opening; the Spital-fields-street requires extension to Old-street, and in connection with this a continuation of Hart-street and the Oxford-street thoroughfares through the northern confines of the Charter-house; the declivity of Holborn-hill must be overcome; the Mall requires opening into Charing-cross; and a road should be formed across Hyde-park and Kensington-gardens; these and many other improvements are urgently required, and have been suggested by many persons, from Gwynn downwards. The success of either the "Regent's Canal" or the "Metropolitan" Railway will greatly influence the amount of traffic at the east; and the effect of the Charing-cross or Victoria station, or both, as western centres will also be greatly felt; all must admit that this conflict, waging at both ends of London, is a subject of the utmost interest to the profession. We cannot have a straight street from St. Paul's to the Queen's palace in the centre of Hyde-park; that was the dream of Colonel Trench and Philip Wyatt, in 1827; but we can have such a central thoroughfare as shall carry the traffic from

Digitized by Google

Piccadilly direct to the eastern focus, opening up the only fit district for the Law Courts, in such a manner that Cannon-street shall be no longer a pudding-bag, and St. Paul's an obstruction to the traffic. Take down the block of buildings between St. Paul's-churchyard and Old Change; give St. Paul's School a site in Doctor's Commons, in exchange for a thorough opening of the churchyard; and let the hallowing influence of the place upon the living, when they have some chance of admiring its beauties, atone for the utilisation of the sacred precincts. Whatever is done, let it be considered with reference "Usui civium decori urbium," and not be apportioned to the clamour of a metropolitan constituency.

In the Discussion which followed, Mr. RICKMAN said that one of the most interesting points connected with the subject was the junction of the railways on the north side of London with those on the south. This it was proposed to effect by a line promoted by the West London Railway, and approved by the North Western and Great Western companies. Continuing the line of the West London Railway by means of the Kensington canal, which belonged to that line, and then crossing the river, it would be connected with the South Western and the West-end and Crystal Palace line, and thus with the Victoria station at Pimlico. With respect to the improvement of the metropolitan communications, at present a divided authority exists in the Board of Works, the Commissioners of Sewers, and the railway department of the Board of Trade. The arrangements for new streets were governed by the lines of sewers, and were affected by the lines of the railways and the position of the termini. London therefore could not be properly treated as a metropolis, unless the three boards now controlling these important subjects were combined.

M. HECTOR HOREAU considered the subject before the meeting to be not only of the greatest importance to the reputation of the profession, but of much social interest, as tending to afford employment to the working classes. In no city was the circulation of traffic more broken or more encumbered than in London, whilst its amount was increasing more rapidly than that of any other place. The streets and bridges were narrow and insufficient. The latter generally had bad approaches, and encumbered the river by the smallness of their arches. A grand general plan should be prepared, showing all the improvements required; and this would render their accomplishment more easy and economical. It could not be the work of one man; but if the work of many it might be brought into proper shape by the Institute, which could not have a more fitting task. M. Horeau urged the expediency of abattoirs outside the metropolis, and prohibiting the nuisance of live cattle in the streets, and advocated the embankment of the river, in order to gain for profitable use the present mud banks, especially between Somerset-house and Westminster-bridge. A well managed municipal loan, or an *octroi*, might produce funds, which would be increased by opening (without crowding) some of the parks, which at present diverted much traffic from its direct route. This might be termed encroachment, but it would really benefit the working classes by supplying the means of improving their streets and dwellings, still leaving them spacious boulevards through the existing parks for air, exercise, and recreation. By some means or other the bad streets and narrow bridges of the metropolis must be improved, and more imposing public edifices erected than those at present standing.

Mr. HEYWOOD said the subject under discussion was so large that no one could give any consideration to it without finding its enormous difficulty. Mr. Rickman's map proved the utter want of forethought on the part of those who had hitherto been allowed to rule our municipal improvements. The lines upon it were exactly such as might have been traced by a spider escaped from an inkstand. He was no advocate for the American system. Square blocks of streets were no doubt somewhat convenient, economical, and conducive to health; but he preferred "London as it is" to living in a town with streets told off by A, B, C, or first, second, third, &c. A medium however might be devised between the rectangular system and the miserable net-work of modern London. Within the present century only two really great improvements had been carried out; Regent-street, and the New London-bridge, with its approaches. These were great works (effected before railways had taught recklessness in hacking and cutting down), and their projectors deserved the greatest credit. In spite of the now crowded traffic, the approaches to London-bridge must still be considered a great metropolitan improvement. Cannon-street he considered only a local improvement. The west-end centre line of communication and the city central line having been thus provided for, it appeared to him that the next great fundamental want had been entirely lost sight of,—namely, a line to connect the one of these with the other. He was not sure that even this great want was not subordinate to that of throwing open the whole of the toll bridges. At present no one could say what the traffic would do for itself if unimpeded by these obstructions. This measure he had no doubt would immediately relieve London-bridge of one-third of its traffic, and in a very little time even more, thus avoiding the expenditure of £40,000 in spoiling the bridge as had been proposed, and rendering the approaches more crowded than at present. All the small measures that had been projected would only add to the difficulty and expense that must at last be met, and rather than adopt them he would let London-bridge become impassable, in the hope of having Southwark-bridge thrown open, as it might be for £250,000. Of the new streets required, the first as already intimated was one which should commence about the Bank, proceeding between Oxford-street and the Strand towards Hyde-park; and then, the bridges being opened, time might be allowed to see what course the traffic would take for itself, and what might be required next. With regard to the railways as connected with the metropolis, he thought that this branch of the subject had been too long deferred. The late John Martin, the painter, a man of extraordinary power of mind, had long ago projected a system of railways round London, very much like that which was being carrried out. But Martin lived half a century before his time. His great schemes had been deferred till they were far more costly than they would have been when he proposed them, and were now being carried out much less efficiently; because, instead of being accomplished as parts of one system, the lines were formed to suit the particular views of different companies, and the public lost the benefit both of cheapness and time in transit, from the disadvantageous positions of the respective stations. He would not advocate concentration. Two bridges of 50 feet wide would be better than one of 100 feet. Those who were officially compelled to stop the traffic of the street knew, as he did, that such stoppages were not at present likely to be avoidable; and they also knew the inconvenience of stopping a huge traffic without the means of diverting it into another channel. The plan of bringing the northern railways to a station in the valley of the Fleet was admirable in many respects, but he should prefer three termini to one. The width of Farringdon-street, great as it was, would not be sufficient for the continual collecting and discharge of traffic all day, and another more eastern terminus was desirable. He thought there could not be a better plan than that of taking the line of the Regent's Canal and continuing it to as near the Bank as possible. New streets rather than wide ones—in order to give alternative lines of communication—were the first requisite; railway communication across the Thames and the improvement of Holborn-hill were secondary points. He hoped the Board of Works would not spend upon the latter object the quarter of a million proposed, which would be much better employed in opening Southwark-bridge. The Thames embankment would give to London that grand feature of embellishment which it so much required, but at the same time it would be more splendid than useful, and would not render any of the improvements he had referred to unnecessary. The Board of Works should contemplate the question in a broad spirit, and not make streets now which in a quarter of a century would be useless. The subject should be dealt with irrespective of cost. The metropolis was rich enough to find the necessary funds. Excepting the improvements defrayed from the crown revenues, all the great modern works had been done by the corporation of London. He believed that the Metropolitan Board of Works, embodying as it did from its constitution the spirit of parochial economy, as commonly understood, would never be able by the system of direct taxation to carry out the great streets that were necessary, in the way the work should be done to supply the necessities of the population. The Main Drainage must be accomplished, and there were at least two spots shown in the map which were fairly entitled to their parks. Considering these, in addition to opening the bridges, new streets, and increased railway accommodation, he was quite certain that ten millions of money would not accomplish all that was required. The widening of Cannon-street, and the rebuilding of one side only, had cost the corporation three quarters of a million, after allowing for the improved ground rents. This however left them

Digitized by Google

the vacant ground at St. Paul's. The cost of metropolitan improvements should only be spoken of in millions, for the streets he suggested, from the Bank to Hyde-park-corner, must cost nearly or quite a million a mile. The great continental improvements, he believed, were never the result of direct taxation. In France they had the *octroi* duty; and the much abused coal-tax in our own metropolis (which he hoped would not be abolished) bore upon an article consumed by every one, and was collected at a very little cost by a body which had been in organised existence for a couple of centuries. It bore a direct proportion to the means of all; for the coals a man burnt was as fair a measure as possible of his expenditure. Its amount was only 1*s.* 3*d.* per ton, but it produced, without unpleasantness in collection, £240,000 a year. By doubling or trebling this an enormous fund could be provided; but if the coal-tax were taken off, as proposed, in 1860, no persons but brewers and other large consumers—the only classes who at present opposed it—would be materially benefited by the change, and the fund from which the great modern improvements had been made would be lost. To a serious thinking mind the growth of London was becoming fearful! They had not the ignorance of their forefathers as an excuse,—they well knew from the calculations of the last half century, including periods of war and pestilence, that the population of London doubled itself in 37 years. The enormous surface to be covered by the future population was a very serious matter for consideration; for, as the distance of the suburbs from the centre increased, so must the use of carriages increase, until the present London streets would be in one huge state of stricture. No police regulations for traffic, nor any expedient for widening existing bridges by overhanging footways, could do any real good; and whilst the value of property required for new streets was daily rising in value, procrastination must increase their cost enormously. In addition to the coal-tax he thought the tax on carriages might be equitably and fairly given to the improvement of the metropolis. There might be a great struggle for it, but it could not be resisted even by the House of Commons. He believed the time was coming when the enormously increasing population of London must find other centres: but if so, it must be from the impossibility of getting to the large centres in the network of alleys shown on the map, for, in relation to the wants of the population, the streets of the metropolis were really nothing but alleys.

Mr. Pocock agreed with Mr. Heywood's principle of distributing rather than concentrating the traffic; and he had the acknowledgment of Mr. Lambert Jones, that in the approaches to London-bridge that principle had been too much overlooked. About the Mansion-house especially all the streets converged to one point, leading necessarily to great confusion. He differed with Mr. Heywood as to the improvement of Holborn-hill. The heavy van traffic from London-bridge station to the Great Western Railway and north and north-western parts of the metropolis, now passed from Fleet-street through Fetter-lane or Chancery-lane, instead of taking its legitimate course from Cheapside to Holborn-hill; and the formation of a level from Skinner-street to Holborn-hill would keep this traffic in its natural route, and prevent the blocking up of Fleet-street and the Strand. Mr. Marrable's plan for the Holborn viaduct had the advantage over the other scheme of enabling the cross traffic to pass under the viaduct; and if Blackfriars-bridge were to be improved in its gradients, and the declivity of Holborn-hill done away with, the present confusion at the foot of Ludgate-hill would be very materially diminished. The street from east to west proposed by Mr. Heywood was of great importance; but in the city itself another vast improvement might be made by widening the line of Gresham-street, at present almost impassable, and extending it westward by removing the Blue-coat School to the fresh air of the country. Money should not be spent in widening streets, but in making entirely new lines with double instead of single frontages, which rendered it practicable to deal with much less valuable property; and this applied to the line from Skinner-street to Gresham-street, which if carried out would relieve Newgate-street. The line from Liquorpond-street to Old-street, or some other line, was necessary to relieve Holborn. The Bank would always be a focus of traffic, and also Charing-cross; but a great deal of traffic which had no business there went to those places simply because no other routes were open to them. London-bridge was not merely a great metropolitan thoroughfare, but it was the main line connecting Kent and Essex. Much traffic passed over it which need not go into the city at all, or at least might as well go over Southwark or Blackfriars bridges.

Mr. Richard Bell advocated the improvement of the quays of the river; but this was a question of cost. For thirty years past nearly three millions a year had been expended on metropolitan improvements, which, comparatively speaking, had been invaluable; but in order to carry out the improvement of the quays of London the best method would appear to be the adoption of a sort of sliding scale; and to purchase the reversionary interest of the freehold property along the sides of the river to the necessary extent. If a well digested plan of this kind were laid down, money might be judiciously invested so as to secure the possession of part of the property in 40 years, and another part in 80 years. At the same time he should deprecate any encroachment on the water way: he would indeed hardly allow a walking stick to be placed in the bed of the river, nor any new bridges on piers to be erected. The obstruction of a bridge on piers affected the tides a mile and a half down the river. This had been proved by the observations made and recorded twice every day for 18 years by the Dock-master of the London Docks. Money however could not be more judiciously expended than in making a good wide quay along the river, by which, amongst other advantages, the passenger traffic from Westminster to the city would be accommodated. Mr. Bell then explained (referring to the map) his proposal for a railway station on the site bounded by Little Moorfields, Milton-street, Fore-street, and Chiswell-street, to be reached by adopting and extending the line of the Regent's canal. This, he observed, would relieve the Holborn line of the traffic from Notting-hill and the north-western suburbs, which at present took that route in preference to the nine miles circuit of the North London Railway, as it would bring it much nearer the Bank. He then proceeded to explain his proposed adoption of the line of the Regent's Canal to Limehouse, and thence by a tunnel, with a gradient of 1 in 150, under the London Docks, using the Thames Tunnel, and joining the southern railways at New-cross. He described the advantages of this plan in relieving London-bridge; and urged the superiority of Fore-street to Farringdon-street as a city railway terminus, in reference to the levels and other circumstances, particularly the narrowness of Newgate-street, and its inadequacy for large traffic from a Farringdon-street terminus.

Mr. C. H. Smith strongly urged the great importance of improving rather than injuring the river, and advocated the embankment of the stream throughout. At present, whilst the narrowness of the river in some parts gave force and rapidity to the current there, carrying onwards the matters in solution, —in the wider parts, as at Hungerford, not only was the mud deposited on the banks, but the stream became so shallow as to be almost useless for purposes of traffic. The Thames being made more available for goods traffic, the streets of London would in consequence be greatly relieved. In any future act of parliament unlimited power should not be placed in the hands of any one individual. This had however been done in the case of the Regent-street improvements, and the consequence was that at the junction of Regent-street and Portland-place there had been a divergence from the straight line originally contemplated.

Mr. O. Hansard urged the advantage of a street from the Quadrant, taking the line of Leicester-square, and so—by a widening of Drury-lane—to the Strand, at St. Clement's Church. This would relieve the Holborn line, and render Blackfriars-bridge, instead of London-bridge, the leading thoroughfare for traffic going to the south side of the river. He also referred to Gwyn's plans for London improvements, published 100 years ago, in which a bridge next Somerset house, and many of the plans now carried out, were anticipated.

Mr. Cates referred to and explained Mr. Pennethorne's plan for a line from New Coventry-street, by Long-acre, crossing Drury-lane, by Carey-street, the new Record Office, Farringdon-market, over Farringdon-street by a bridge, and terminating at the General Post Office. This would save the expense of altering Holborn-hill. He illustrated, by reference to the same plan, the extreme difficulty of laying out a line in this direction without interfering with the numerous public institutions which stood in the way of an absolutely straight line.

Mr. Godwin begged to say one word in fairness, to emphasise the importance of the projected extension of the West London Railway. This would give the Great Western and North Western railways the important advantage of access to the Pimlico station; and, if an act were obtained (for which strong interest was being made), to Charing-cross, the project would join the whole of the

Digitized by Google

lines north of the Thames with those on the south, and remove the absurdity of the present railway system of the metropolis. London was the only town in the United Kingdom in which a person wishing to pass through it from one railway to another was compelled either to stop at an hotel or take a cab from one station to another. The West London Railway had been exposed to the greatest obloquy, yet now no less than five projects had been submitted to Parliament this session in order to render it available, and three of them had passed the standing orders committee. This should serve as an encouragement to all who conceived a good idea, to submit even for years to the scoffs and ridicule of a large majority against them. The West London line thus extended, must one day be a good line. The North Western Railway Company, he believed, had agreed to subscribe £100,000 to the scheme, which would unquestionably materially relieve the traffic of the streets of London.

ELY CATHEDRAL.

It is proposed to restore the central octagon and lantern of this cathedral as a memorial of the late Dean Peacock, from a twofold motive, it being the portion of the fabric which appears naturally next to claim attention, and also that to which the energies of the late Dean had been for some time directed, and which he was so anxious to see completed, as may be gathered from a statement he drew up and issued in 1853, respecting the works already finished in Ely Cathedral, and those which then remained to be carried out. In this statement the following passage occurs:

"Of all the works which remain to be undertaken, the most considerable and the most important is the restoration of the lantern, including the decoration of the vault, the substitution of windows of an appropriate character for those which now disfigure it so seriously, and the addition of the outer corona of turrets and pinnacles as originally designed by Alan de Walsingham."

In the course of last summer the late Dean was engaged in preparing another account for the public, enumerating in detail the works executed since 1853, from which it will be seen that the restoration of the octagon and lantern was still, in his view, the chief undertaking to be accomplished for the completion of the great work of improvement. The eight windows of the upper octagon, which are now examples of the meanest description of "carpenter's gothic," were reduced (probably by Essex) from four lights to three, and shortened more than three feet; the footings of the mullions and jambs of the windows are still in existence, so as to leave no doubt about the possibility of their correct restoration, though there exist no corresponding means of restoring the tracery. No difficulty would, however, present itself in the restoration of the painting of the vault, as the traces of the ancient decorations, both in outline and colour, are too manifest to be mistaken.

The case is very different with respect to the outside of the octagon (the whole of which, it may be observed, is constructed of wood), the upper timbers of which are in a ruinous state, and which has undergone so many changes from the repeated patchings rendered necessary by the decay of the materials (so little calculated to resist the action of the weather) that it would be impossible to reproduce with certainty its original form. In some ancient prints representing the cathedral, flying buttresses are indicated, and the forms of the upper tier of windows are altogether different from the present; but such representations are generally so vague and unfaithful that they are of little or no use in aiding the restoration even of the ancient features, much less the details of the architecture. If the design of the great architect Alan de Walsingham had been perfected, eight lofty turrets at the angles of the greater octagon, and four lofty pinnacles in the middle of its four larger sides, connected by a double range of open parapets of an enriched character, would present a corona of singular beauty and boldness, concealing altogether, or nearly so, the smaller octagon within, and rendering the architectural details comparatively unimportant.

A resolution has been lately passed by the Dean and Chapter authorising Mr. Scott, the architect to the cathedral, to prepare a plan for the restoration of the octagon and lantern, in order that this work may be undertaken forthwith as the most fitting public memorial of the zeal, energy, and liberality displayed by the late Dean in the great improvements executed under his superintendence in the eastern and western portions of the fabric. A committee has also been formed for the purpose of promoting the work.

ON THE RELATIVE POWER OF METALS AND ALLOYS TO CONDUCT HEAT.—*Part I.**

By F. Crace Calvert, F.C.S., and Richard Johnson, F.C.S.

Metals and their alloys being now so extensively employed in arts and manufactures, and for instruments of precision, we have thought that it would be interesting, in a scientific or commercial point of view, if we were to examine their conductibility carefully and completely.

To enable us to determine with accuracy the conducting power of all the ordinary metals, and of seventy of their alloys and thirty of their amalgams, we had to find out a new method of determining the conducting power of metals; for the process followed by M. Despretz could only give results to be relied upon for a few of the best conductors, such as silver, gold, and copper. Further, his process, which consists in having a long and thick bar of metal, so as to allow holes to be drilled, in which mercury and the bulb of a thermometer are inserted, would have required a large quantity of each metal in a state of purity, the labour of obtaining which, even comparatively pure, is well known. Also from the fact of mercury being employed, we should have been unable to ascertain the conducting power of such important alloys as brass and bronzes, and could not have applied to the process of amalgams.

The method which we have followed gives such consistent results, that we have not only been able to determine the influence exercised on the conducting power of metals by the addition of one or two per cent. of another metal, but also to appreciate the difference of conductibility of two alloys made of the same metals, and only differing by a few per cent. in the relative proportions of the metals composing them. At the same time the conditions theoretically required in order to obtain results independent of everything but the nature of the substances, are not very rigorously fulfilled, so that the term "conducting power" as used by us must be understood in a somewhat qualified sense, and as having relation to our method of determining it. We believe, however, that the ratios of the conducting powers as determined by our method do not differ from those of the real conducting powers.

The apparatus which we used is composed of a deal box with a cover, and painted white externally and internally. Inside this box are two vulcanised india-rubber square vessels; the larger vessel, B, is capable of containing 336 cub. cent. of water. The smaller vessel, C, has a capacity of 90 cub. cent.

All sensible radiation and conduction were avoided, and the rise of temperature in this vessel during the experiment must have been entirely due to the heat conducted by the square bar of metal used. This bar is 6 centims. long and 1 centim. square, and is so arranged in the experiment, that 1 cub. cent. is in the vessel B, 1 cub. cent. in the vessel C; 3 cub. cent. are covered by the sides of the boxes through which it passes; and the last 1 cub. cent. is covered with a piece of vulcanized india-rubber tubing, and the whole made secure from any leakage by lining the sides of the holes, through which the bar passes, with a varnish made of caoutchouc dissolved in benzine. The bar is placed 54 millims. from the bottom of B, and 12 millims. from the bottom of C.

A small jet of steam, generated in a flask, the water in which is kept boiling during the whole of the experiment, enables the operator to keep up a constant temperature of 90° in the vessel B, during the quarter of an hour which the experiment requires. The operator looks attentively at the scale of the thermometer in vessel C, and as soon as he perceives the column of mercury rising, he carefully marks the second and minute dials of his watch, and makes similar marks fifteen minutes further on. It must be borne in mind that it was not the absolute quantity of heat communicated to the bar in vessel B which was determined in vessel C, but the relative facility of conduction by various metals, all circumstances being the same. The best proofs that we can give of the accuracy of the process are—1st, that the series of alloys which conduct heat in the ratio of the equivalents of the metals composing them would not have shown such a coincidence between the observed and theoretical results if our process had presented any serious defects. 2nd, that we have been able to determine with accuracy the marked influence exercised by the addition of 1 per cent. of a metal to another metal. 3rd, it will be seen further on in the paper, that we have determined with precision, that in copper bars, having different conducting surfaces, the observed result agrees with the calculated one.

* Abridged from a paper read before the Royal Society.

Digitized by Google

As the determination of the power of metals to conduct is of great importance, a detailed record is given of the results obtained; the following are some of them:—

Name of the metals.	Temperature of the 50 cub. cent. of water before beginning.	Temperature of the 50 cub. cent. after 15 minutes.	Conductibility found.	Mean.	Conductibility. Silver=1000.
Silver 1000/1000 ...	19·8°	51·6°	31·8	31·9	1000
	19·7	51·7	32·0		
Gold 1000/1000 ...	14	45·4	31·40	31·30	981
	13·6	44·8	31·20		
Gold 99/1000 ...	20·3	47·3	27·	26·80	840
	20·3	47·0	26·7		
	20·	46·7	26·7		
Copper (rolled)	19·5	46·3	26·8	26·95	845
	20·	47·1	27·1		
	21·	48·0	27·		
	20·5	47·45	26·95		
Copper (cast)	21·30	47·2	25·90	25·87	811
	21·45	47·3	25·83		
Zinc (rolled)	18·4	39·0	20·6	20·45	641
	19·9	40·2	20·3		
	18·5	38·9	20·4		
Zinc (cast vertically)	19·6	39·8	20·2	20·03	628
	19·2	39·1	19·9		
	14·0	35·	20·		
Zinc (cast horizontally)	20·6	40·	19·4	19·40	608
	20·8	40·2	19·4		
Malleable iron	18·70	32·6	13·9	13·92	436
	19·05	33·	13·90		
Tin	20·5	34·	13·55	13·45	422
	21·2	34·6	13·4		
Steel	15·2	27·8	12·6	12·65	397
	15·5	28·2	12·7		
Cast-iron ...	14·9	26·4	11·50	11·45	359
	15·6	27·0	11·40		
Lead	20·5	29·70	9·20	9·17	287
	18·3	27·45	9·15		

Influence of Molecular Condition.

We found that the conducting power of several metals was different when they were rolled out into bars, or when cast. Thus for example,—

	Conductibility found.	Conductibility. Silver=1000.
Rolled copper	26·95	845
Cast copper	25·87	811

It is probable that the reason why rolled metal conducts heat better than the same metal when simply cast, is that the molecules composing the rolled metal are in closer contact than those composing the cast metal, owing to the process of rolling; and it is worthy of observation, that this view agrees with Mr. J. P. Joule's theory, that heat travels in bodies by the vibration of matter, and not by the fluid called caloric travelling between the interstices of the molecules.

Influence of Crystallisation.

The influence of the molecular arrangement is clearly illustrated in the following examples, where it is seen that the conducting power of zinc, antimony, and bismuth is modified according to the axes of crystallisation. Thus the conducting power of zinc is different if the sample for experiment is cast horizontally or vertically; for example,—

	Conductibility found.	Conductibility. Silver=1000.
Zinc cast vertically	20·03	628
Zinc cast horizontally	19·40	608

If these two square bars be broken and examined, they present a very great difference. The one cast vertically has four axes of crystallisation, all starting from the centre and proceeding towards each angle of the bar. The one cast horizontally has one centre line or axis of crystallisation, which divides the square bar into three parts.

The results obtained with antimony are the following:—

	Conductibility found.	Conductibility. Silver=1000.
Antimony cast vertically... ...	6·12	192
Antimony cast horizontally ...	6·85	215

We shall refer to the extraordinary influence exercised by crystallisation on conduction of heat when we examine some of the alloys.

Influence of small amounts of Impurities on the Conducting Power of Metals.

We have thought that it would be useful to ascertain the influence which 1 per cent. of a metal exercises when added to another, and these are the curious results obtained with gold and silver:—

	Conductibility found.	Conductibility. Silver=1000.
Pure gold	31·31	981
Gold with 1 per cent. of silver ...	26·80	840

Therefore the addition of 1 per cent. of silver, the best conductor, to gold, diminishes its conducting power nearly 20 per cent.

We have observed much more marked examples of the diminution of conductibility of a metal by the addition of 1 per cent. of another metal; for example, whilst the conducting power of pure mercury is 21·60, it is only 13·15 when amalgamated with 1·25 per cent. of tin. Professor W. Thomson having lately discovered that a small quantity of various metals added to copper greatly modifies the conduction of electricity by this metal, we deemed it advisable to try if the conduction of heat by copper would also be altered if we were to alloy it with 1 per cent. of various other metals. We were fortunate enough to obtain results which coincide with his, namely, that some metals increase the conduction of heat by copper, whilst others diminish it.

We have also examined the influence which carbon exercises on the conductibility of iron, and we hope that the results observed will prove useful in a commercial point of view; for as seen by the figures obtained, the difference is about equal to 18 per cent. The following are the results:—

	Conductibility found.	Conductibility. Silver=1000.
Malleable iron	13·92	436
Steel	12·65	397
Cast iron	11·45	359

We have also made a great variety of experiments with the view of ascertaining if there be a general law in connexion with the conduction of heat by alloys, and although we could not trace any general rule, still we observed several useful facts.

The conduction of heat by alloys may be considered under three general heads:—

1. Alloys which conduct heat in ratio with the relative equivalents of the metals composing them.

2. Alloys in which there is an excess of equivalents of the worse conducting metal over the number of equivalents of the better conductor, such as alloys composed of 1Cu and 2Sn; 1Cu and 3Sn; 1Cu and 4Sn, &c., and which present the curious and unexpected rule that they conduct heat as if they did not contain a particle of the better conductor; the conducting power of such alloys being the same as if the square bar which we were examining was entirely composed of the worse conducting metal. A not less remarkable fact is that the alloys of a series such as those of 2 equivalents of bismuth and 1 of lead, 3Bi and 1Pb, 4Bi and 1Pb, 5Bi and 1Pb, all conduct the same, viz., about 1·9, the various increasing quantities of lead exercising no influence on the conductibility of the alloys. The results obtained with this class of alloys are most important to engineers; for it will be seen in the case of the alloys of brass and bronze, that no increase is gained in the conductibility of an alloy by increasing the quantity of a good conductor; nay, in many cases it would be a decided loss, unless a sufficient quantity of the better conducting metal be employed to bring the alloy under the third head.

3. Alloys composed of the same metals as the last class, but in which the number of equivalents of the better conducting metal is greater than the number of equivalents of the worse conductor; for example, alloys composed of 1Sn 2Cu; 1Sn 3Cu; 1Sn 4Cu: in this case each alloy has its own arbitrary conducting power; the conductibility of such an alloy gradually increases and tends towards the conducting power of the better conductor of the two metals composing the alloy.

Before describing the experiments which relate to these three classes of alloys, we deem it advisable to state, that from the numerous assays which we have made, we are led to believe that the conduction of heat by alloys is greatly modified by the crystalline system to which each of the metals composing them belongs, or by the peculiar crystalline form of its own crystals; for we have observed that some of the crystallised alloys of copper and tin, and copper and zinc, have a special conducting power of their own; whilst the alloys which present little or no crystallisation have a conductivity which is in ratio to the equivalent quantities of the metals composing them.

The method which we have followed to calculate the theoretical

Digitized by Google

conducting power of our alloys is the following:—Multiply the per-centage quantity of each metal by the respective conducting power of that metal, add the results together and divide by 100; for example, in the alloy Pb 3Sn,

Pb 36·99 × 9·17	= 339·19
3Sn 63·01 × 13·45	847·48
	100)1186·67

11·86 (theoretical conducting power of alloy.)

Class I.—The first class of alloys are those which conduct heat in the ratio of the conductibility of the metals composing them. This class is represented by the alloys of tin and lead, and tin and zinc.

These alloys are the only ones which conducted heat as above stated; and from experiments which will be described further on, we believe that the metals composing these alloys are simply mixed, and not combined together.

Class II. Alloys containing an excess of the worse conducting metal.—The study of this class of alloys being most interesting, we have made many experiments in order to discover why the presence of one metal completely annihilates the conducting power of the other, especially when the latter is the better conductor of the two.

It will be perceived, on looking over the results obtained from experiments on alloys of lead and antimony, that all these alloys conduct heat almost as if the square bars examined were composed of pure antimony, the conducting power of which is 6·12; for if lead, which has a conducting power of 9·17, had influenced the passage of heat through the bars, the conducting power of the alloys would have been much higher, as shown by the column of theoretical conductibility.

The same results were obtained with the series composed of bismuth and antimony.

We now describe the most important series of this class of alloys, namely, that consisting of those composed of tin and copper.

Copper and Tin.

Formula of the alloys and percentage.	Conductibility found.	Mean.	Calculated.	Silver = 1000. Found.	Silver = 1000. Calculated.
Cu = 34·98 Sn = 65·02	13·2 13·3	13·25	17·80	415	558
Cu = 21·21 2Sn = 78·79	13·8 13·7	13·75	16·08	431	504
Cu = 15·21 3Sn = 84·79	13·6 13·4	13·50	15·33	423	481
Cu = 11·86 4Sn = 88·14	12·8 13·1	12·95	14·92	406	468
Cu = 9·73 5Sn = 90·27	12·6 12·7	12·65	14·65	396	459

It is very interesting to observe, that although these alloys contain such different quantities of copper, viz. from 9·73 to 34·98, and this of a good conductor of heat, still no influence is exercised by it on the conductibility of the alloys, for they all give the same results as if the square bar experimented upon were composed of pure tin. Another fact, which increases the importance of the bronze alloys, is the difference which they present in their conductibility when they contain an excess of copper, not only with regard to the above series, but also between each alloy, all of which have a conducting power of their own.

Copper and Tin.

Formula of the alloys and percentage.	Conductibility found.	Mean.	Calculated.	Silver = 1000. Found.	Silver = 1000. Calculated.
Sn = 38·21 3Cu = 61·79	15·7 15·8	15·75	21·37	494	670
Sn = 31·73 4Cu = 68·27	4·9 5·1 4·95 4·90	4·96	21·88	155	686
Sn = 27·10 5Cu = 72·90	6·5 6·6 6·6	6·6	22·50	207	705

The results obtained with Sn 4Cu were so extraordinary that the experiment was carefully repeated; but with the same results as before.

We concluded that an alloy of tin and copper containing 68 per cent. of the latter metal, has a conducting power five times less than it should have according to theory. From the above results it is highly probable that these alloys of tin and copper, and especially the three last, are definite chemical compounds; for if they were mixtures, they would conduct heat in ratio to the equivalents of the metals composing them, and would not each have a peculiar and different conductibility. These views are substantiated by experiments which we have made with square bars composed of sectional parts of copper and tin.

These results appear to us perfectly to substantiate our views, viz. that these alloys are definite chemical compounds, and not a mixture of metals; for if they were the latter they would conduct heat as the bars, and would not have a conductibility of their own. With bars composed of a row of cubes of copper and tin soldered together in various orders, the conductibility was nearly the theoretical conductibility of an alloy containing the like proportion of the two metals.

Notwithstanding these facts, we were not prepared for the curious results which we obtained with a bar composed of two longitudinal bars of tin soldered to two of copper, and placed in juxtaposition; for although it contained in 100 parts the same weight of tin and copper as the bar in which cubes of copper and tin alternated, it conducted heat at quite a different rate; in fact, its conductibility was the same as if the bar was entirely composed of pure copper, and did not contain half its bulk of tin.

These interesting results were confirmed by having similar bars made of copper and zinc, and copper and lead.

Class III. Alloys in which there is an excess of the good conductor.—Having already described the peculiar properties presented by four of the bronze alloys, viz., those of Sn 2Cu, Sn 3Cu, Sn 4Cu, and Sn 5Cu, we should have nothing more to add to them, if we did not wish to illustrate the extraordinary influence which tin exercises on the conductibility of copper, and also to show that when there is a great excess of a good conductor in an alloy, it overcomes the resistance of the bad conductor, and in consequence the conductibility of such alloys increases with the proportion of the good conductor.

	Obtained.	Calculated.	Silver = 1000. Obtained.	Silver = 1000. Calculated.
Sn = 27·10 5Cu = 72·90	6·60	22·50	207	705
Sn = 15·68 10Cu = 84·32	9·80	23·90	307	749
Sn = 11·03 15Cu = 88·97	12·82	24·50	402	768
Sn = 8·51 20Cu = 91·49	14·85	24·81	465	778
Sn = 6·83 25Cu = 93·17	15·15	25·02	475	784

Alloys of Zinc and Copper.

The reason why we have kept these alloys all together, and have not divided them so as to bring them under the last two divisions, is, that they have a tendency to come entirely under the last division. We say a tendency, for they do not offer the distinctive degrees of conductibility that the alloys of copper and tin or bismuth and antimony present; but this may be due to the conducting powers of copper and zinc being within a few degrees of one another,—cast copper being 25·87; cast zinc 20·03.

Conductibility of Copper and Zinc Alloys.

	Obtained.	Calculated.	Silver = 1000. Obtained.	Silver = 1000. Calculated.
Cu = 49·32 Zn = 50·68	21·95	22·92	688	718
Cu = 32·74 2Zn = 67·26	13·65	21·91	428	687
Cu = 24·64 3Zn = 75·36	16·95	21·44	531	672
Cu = 19·57 4Zn = 80·43	18·80	21·14	589	663
Cu = 16·30 5Zn = 83·70	19·00	20·95	595	657

Digitized by Google

It is probable that Cu 2Zn and Cu 3Zn are definite compounds, for not only have they a special conducting power of their own far below that of the metals composing them, but also they are perfectly crystallised. The most splendid of all the brass alloys is the alloy CuZn, which is of a beautiful gold colour, and crystallises in prisms often 3 centims. long. These crystals are also interesting on account of their extraordinary elasticity. It is surprising that so cheap an alloy has not been employed in commerce, for no commercial brass contains more than 30 to 35 per cent. of zinc, whilst the above one contains 50·68 of this metal. The only explanation that we can give of this fact is, that if copper be alloyed with more than 50 per cent. of zinc, the alloys formed do not possess the colour of brass, but become white as zinc, and therefore the manufacturers have never tried to unite these metals in the exact proportions given above. We say exact, for it is remarkable that a variation of a few per cent. in the relative proportions of the two metals no longer yields the beautiful alloy which we have noticed, but only a white and comparatively useless one.

We also thought that it might be useful if we were to analyse the following commercial alloys, and determine their respective conducting powers.

		Found.	Calculated.	Silver =1000. Found.	Calculated.
'Yellow brass' ...	Cu=64·0 Zn=56·0	17·80	22·73	558	712
'Pumps and pipes'	Cu=80·0 Sn= 5·0 Zn= 7·5 Pb= 7·5	13·60	22·57	426	707
'Mud plugs'	Cu=80·0 Sn=10·0 Zn=10·0	12·60	24·00	394	754
'Large bearings'	Cu=82·05 Sn=12·82 Zn= 5·13	11·00	23·97	345	751

It is extraordinary to find what a low conducting power these alloys possess; for with the exception of the alloy named "yellow brass," they do not conduct heat better than wrought and cast-iron. This is due to the impurities of the metals employed, and shows the advantage that there will be in substituting for them some of the much cheaper alloys above described.

ON DESIGN IN INTERIOR ARCHITECTURE.*

By Sydney Smirke, A.R.A.

(*Concluded from p.* 103.)

But it is time to quit this subject of staircases, and I hasten to enter the apartments to which they lead. Let us first, however, stay our steps for a few minutes, and parley on the subject of the passage or corridor, that we have to traverse before entering the apartment.

Good taste, and indeed common sense, seems to point out the propriety of rendering the architectural aspect of a passage somewhat conformable in style and treatment with the more important object to which it leads, whether it be a church or a chamber. The eye and the mind would thus be in some measure prepared for, and attuned to the subject upon which it is about to be exercised; care, however, being always taken to keep this passage subordinate and comparatively subdued, so that no danger may be incurred of disappointment. Many modes present themselves of giving architectural effect to this passage; variety of light and shadow is an important means of doing so. We all feel the beautiful effects of this variety in natural scenery,—those glimpses of sunshine, those alternations of gloom and cheerful daylight, which are such charming incidents in a forest scene. Analogous effects are obtainable in our own art. A long passage may be greatly diversified by a judicious breaking up of its length with alternations of *chiaroscuro*. With the same object in view—of diverting the attention, and relieving the monotony of a long corridor—we may often perceive the advantage of placing an object of interest for the eye to dwell on, such as a picture or a piece of sculpture at its termination, or at a turn in its course.

In Italy, where our art was always so intimately related to the painter's art, and where the architect scarcely ever failed to see his object with a painter's eye, examples of these tasteful arrangements abound. The most beautiful passage in the world is probably that which Raphael designed, and, with his pupils, executed at the Vatican Palace. Independently of its frescoes, of world-wide celebrity, the proportions of its arches and piers give it an unspeakable grace. Yet, beautiful as it is, the subordination to which I have just adverted has been so well observed that the stanze to which it gives admission lose nothing whatever of their beauty by the contrast; that beauty being of a grander and more elevated character. Whilst on the walls and vaulting of this corridor are depicted light arabesques and playful ornaments, the walls of the stanze bear some of the grandest masterpieces of the genius of painting.

In the vaulted corridors which surround the great Flavian amphitheatre we have another very remarkable instance of correct judgment in our art; a most dignified work of architecture, and strictly consistent in character with the great building of which it forms a part.

There can be little doubt that the imposing corridors which surrounded this, the greatest as well as the most popular public building in the ancient metropolis of the civilised world, were repeated over the whole empire, and became not only the model on which all other works of a like nature were subsequently erected, but the fertile parent also of those beautiful arcades which so frequently court our admiration in works both of the middle and the later ages.

These are indeed two pre-eminent examples which I have cited; and it may be thought, that as in moral training deeds of heroic daring seem to be almost discouraging examples to set before ordinary minds, which need rather lessons of conduct in ordinary life, so those noble works of the highest grades of art, it may be thought offer no available materials for our imitation or study in fulfilling the humbler tasks that fall to the lot of most of us. It is not so however; a right principle is applicable alike to great things and small; and I consider that the rule to which I have just adverted, and which I wish to urge on your attention, viz., that which teaches us to render easy passage conformable in style yet subordinate in treatment to the apartment to which it leads, is of universal application. Let us now proceed to the consideration of those apartments towards which we have been advancing.

There are few objects connected with our art that have been more frequently dwelt on by those who have undertaken to be our guides and monitors, than the right proportions to be given to rooms.

Vitruvius led the way, and subsequent theorisers have laid down, sometimes very dogmatically, their views of just proportions. I find, however, in the actual practice of the ablest men such extreme diversity, and I observe pleasing effects producible by the adoption of such widely different proportions, that I find myself, I confess, much inclined to be somewhat incredulous of all these theories. Certainly if beauty could be thus reduced to a formula, and the proper relation indisputably established between the length, breadth, and height of every room, a royal road would be cleared for us, which would be at least very convenient both to those who teach and to those who learn. I fear I can scarcely hope to furnish you with such a desirable help in your studies. I find rooms of universally admitted beauty, yet of almost every geometrical figure. I have heard of the room in the museum of Florence, the Tribune it is called, which contains the Venus di Medici, spoken of in terms of rapturous approval for the beauty of its form and proportions: this saloon is an equilateral octagon on plan. I have known square rooms greatly admired,—such for example as the saloon in Cobham Hall, which is usually pointed to as one of the *chefs d'œuvre* of Inigo Jones. Who is there that is not charmed with the proportions of the Pantheon at Rome? This, you know, is circular. The classical teacher of our art, Vitruvius, seems to contemplate only rectangular forms, and directs us to adapt the double cube and the cube and a half, whether for a temple or a trichlinium. The Sistine chapel, attached to the Papal palace, upon which the best art of Italy in its best days was expended, is a triple cube, viz., 133 by 44. Whilst of modern French, Italian, and English teachers, each seems to have his own special favorite proportion.

The truth I believe to be, that so bounteously have we been

* Lecture delivered at the Royal Academy.

Digitized by Google

endowed, and so liberally have the laws of beauty in form and proportion been framed, that there exists in fact an endless variety of beautiful forms and proportions. My impression is that it is as little consistent with truth to lay down any one definite form or proportion as the best, as it is to extol any one particular curve as the line of beauty. I believe that there are as many pleasing proportions to be given to rooms, as there are pleasing harmonies of colour and sound.

The purpose of a room must always be an important guide in determining the form and proportions to be given to it. If planned so long in proportion to its width as to remind us of a passage, it loses its distinctive character, and creates a false impression, which it can never be good art to do. It is indeed obvious, that a consideration of the special fitness of a room for its destined uses must always greatly influence its proportions. The octagon form, so much affected by our ancestors in planning their chapter-houses, owes its origin probably far more to the propriety of that form for a chamber intended for the convenient assemblage of the members of the chapter sitting in council, than to any intrinsic architectural beauty, however unquestionable that beauty may be.

This fitness to its purpose should, in truth, be among our very first objects of consideration in designing a room. But it is the diversity of those objects to be kept in view which complicate our art, and render the task of an architect often very difficult. In a public hall, for example, he has to consider not only its agreeable proportions, but its acoustic properties: its aptness for seeing; its capacities for lighting and ventilation; the most serviceable distribution of its means of ingress and egress; and indeed many other considerations: among all which he has to attach to each its relative importance, to determine correctly and judiciously to what extent one object may give way to another, and where a sacrifice can best be made. Unfortunately for our art, whilst these conflicting considerations are taxing the judgment of an architect, the critic stands by regardless of all these embarrassments, and tests the beauty of our work perhaps by the inflexible rules of the dogmatist on whom he may have happened to pin his faith. I am however very far from being inclined to say that the proportions of a room are æsthetically arbitrary.

Were I myself disposed to dogmatise on this subject, I should say that whatever form may be given to a room it should be a definite, unambiguous form, and there should be no doubt as to the nature of its apparent proportions. If square, it should be truly square; and if it depart from the square that departure should be obvious and decided. For the same reason I should condemn a slightly oval form, or an octagon with two parallel sides slightly elongated. It is obvious that for the same reason all rhomboidal plans, and any other anomalous departure from regular rectangular figures offend the eye. In these however and other like matters we must consult the genius of the place, and submit to be overruled by necessity and expediency.

In thus recommending symmetrical forms, I must by no means be understood to urge on you the constant adoption of simple geometrical figures. Beauty and convenience alike suggest variety in the boundary lines of an apartment, especially an apartment adapted to social uses. The deeply embowed recesses that occur so often in our own domestic architecture—far more so indeed than in continental architecture—are a source of great beauty, varying the lights and shadows, and breaking the monotony of parallel lines.

The oriel window of our old halls and mansions, whatever may have been its purpose, is always a pleasing feature, and the deep bays in the principal galleries of those picturesque mansions happily concealed their usual comparative narrowness. "These be pretty places for conferences," says Lord Bacon; and his remark in a lively and agreeable way truly indicates the commodiousness of those cheerful recesses.

The Italian masters, with too sensitive an eye not to be struck with the hardness and dryness of an equilateral rectangular form of room, adopted not unfrequently a very happy and effectual mode of concealing, correcting, or obviating it, by converting the upper part of the room into an octagon, supporting the walls at the angles either by arches or niches, without any material encroachment on the area of the rectangle. This contrivance is in truth of early date. At the Castelle dell'Uovo, at Naples, is a very stately hall, of magnificent dimensions, where this expedient has been most effectively and strikingly carried out.

In ecclesiastical architecture this corbelling over is of frequent occurrence. Wherever indeed an octagon lantern or spire is placed on a square tower, a false bearing is produced that almost necessitates such a mode of construction. This mode of growing an octagon out of a square led to a variety of contrivances for the decoration of the couch, or spandrel space, formed by the overhanging of the four diagonals; among which contrivances, perhaps the most ingenious and elaborate, if not the most beautiful, were the pendentives devised by Saracenic architects, whereby the soffit of the couch was sculptured into a multitude of very small groined arches, rising in a succession of tiers, corbelling over, and forming those singular stalactitic ceilings so characteristic of Moorish and Saracenic architecture.

The most usual form of ceilings in the Classic era, where the spans were great, continued for a long time to be the vault. The remains at Pompeii, and indeed of Roman art over all Europe, show that the semi-cylindrical vault was the customary mode of construction; often varied however by groining.

The diagonal lines of this cross-vaulting were usually executed by Roman builders in a careful way with well-jointed masonry or brickwork, the spandrels being filled in with a more rudely worked and lighter material.

It was from this particular mode of workmanship that mediæval vaulting was derived: the more solid diagonals becoming still more visibly and strongly pronounced, first appearing as square ribs, and ultimately assuming the more familiar aspect of ribbed vaulting; the spaces between the ribs being built, as in the Pantheon and other Roman buildings, with sometimes volcanic scoria, and sometimes tufa. So in mediæval buildings—as at Glastonbury and elsewhere—a sort of calcareous tufa, and still more commonly of chalk, was used.

It is not however to be forgotten that during the whole of these periods, from the Greek era and earlier, downwards, flat ceilings of timber may have never ceased to be formed, although their perishable nature has deprived us of existing examples. We read in Homeric buildings of beams painted in bright colours, and even encased in plates of ornamental metal-work; but we can now trace only indications of their existence in the apertures left in the masonry for their reception. In later Classic times representations of flat timber ceilings occur not unfrequently in frescoes. In the fifteenth century—by far the most actively inventive period of modern art—Italian architects contrived an entirely novel form of ceiling, for which neither Classical nor Mediæval art had furnished the slightest precedent. They reconciled the convenient form of the flat ceiling to the equally familiar but more elegant form of the vaulted ceiling, by uniting with the former a deep cove, or half-vault, springing from the walls. This was first executed in wood,—the earliest examples of which, so far as I know, occur at Venice, as at the Academy; but afterwards these coves came to be formed in plaster,—a mode of construction that hardly can date earlier than the beginning of the sixteenth century. It must be admitted that there is a want of truth in this coved form of ceiling, for which the only plea in justification is the very pleasing mode it affords of obviating the heavy depressed appearance of a flat ceiling. Attempts were made it is true to obtain, in a more truthful mode of construction, somewhat the same effect by turning in masonry an extremely flat elliptical vault. But Sansovino, who ventured this expedient in the Libraria at Venice, was thrown into prison and fined 1000 scudi for his failure,—a fate which must have powerfully operated on the minds of his brother artists in overcoming their scruples bout plaster coves.

Another mode of forming ceilings which was much practised by early Italian artists, was to frame them of deep coffers wholly of wood, often richly painted and gilt. There are few palatial apartments within my own knowledge equal in grandeur of effect to the magnificent halls (now in a melancholy state of decay) of the palace built at Mantua by Giulio Romano. The ceilings are for the most part so constructed, and the gigantic force of their coffers, relieved by the extreme richness of their carving, proclaims the master-hand of the great artist who designed them. At Venice, and at the Farnese palace at Rome, we have also very noble examples of this form of ceiling.

In the nearly contemporary flat coffered ceilings executed in England by Holbein, as in the Chapel Royal, St. James's, and probably by the same master in the Savoy Chapel, we have ceilings designed on the same principle, although but weak and faint imitations; yet even these are almost bold when compared with the ceilings lineally descended from them in later times. The Stuccatori of the last century discarded this coffered and tra-

Digitized by Google

beated form of ceiling, and introduced a more playful fantastic style of decoration, better suited to their special material; until, towards the close of the century, their art in its turn succumbed and gave way to plaster castings of the feeblest kind.

Having now briefly touched on the subject of the forms and proportions of rooms, we will pass on to the equally important subject of giving light to them.

So much of the architectural effect of a building, for whatever purpose it may be destined, and so much of its aptness and convenience, depends on the mode that may be adopted of lighting it, that it is certainly a matter demanding your especial attention and study; the more so, because no definite general rules can be laid down for the proportioning of windows to the area they have to light.

Much obviously must always depend on the purpose of the room to be lighted; much also on the nature of the medium through which the light passes, and on the position of the windows; and above all perhaps on the degree of intensity of the light obtainable from without. The practice of Italy, for example, would be a very unsafe guide for us in our more uncertain climate and more sombre atmosphere. Here the most ample panes and the clearest glass will often hardly suffice; whilst in Italy, such is the penetrating fervour of the sun, that sometimes men are content, as at St. Miniato, near Florence, with the light that can make its way through slabs of alabaster. We know indeed that lapis specularis was much used for this purpose in classic times.

Then again the light that is obtainable in an open country and a crowded street requires totally different proportions; whilst a window filled with stained glass will need, in order to afford a given volume of light, an extent of perforated surface that would be altogether disproportionate where clear glass is used. In the absence then of any definite rule, it becomes especially necessary by habitual observation and comparison, to learn our wants and our resources.

On a former occasion I adverted to the importance of the study of the effects of light and shadow in the design of exterior architecture. At least equal importance is to be attached to this consideration in interior design.

In the production of grand effects *chiaroscuro* plays an important part; for the quality of grandeur depends not only on largeness of dimensions, but on a proper treatment of lights and shadows. When the form of an apartment or hall is simple the impression of grandeur can perhaps only be produced by real size; but when the form is complex, a new element of grandeur arises in the diversity and breadth of its light and dark parts. It is to this, far more than any other cause, that we are to attribute the powerful impression made on the mind by the interior of a Gothic cathedral. The burst of light from the transept breaking the monotony of the nave,—the light on the screen brought out into prominence as seen against the dim haze of the choir,—the splendour of the clerestory contrasted by the comparative gloom below; these are all effects wholly due to *chiaroscuro*, and constitute perhaps the chief charm of those fine architectural compositions.

It has always appeared to me a subject of deep regret that the undue interference of incompetent judges prevented Sir Christopher Wren from carrying out his first and perfectly original idea for St. Paul's Cathedral, where the effects produced by the double vaulted aisle surrounding the octagonal nave would have been truly surprising: my conviction is, that had that design been carried out, an interior architectural scene would have been the result wholly unparalleled in any building in Christendom.

The present is of course not a proper occasion for discussing the utilitarian requirements of a room. No doubt a room destined for pictures must have its light admitted far differently from a room where sculpture is to be exhibited, and both widely differ from the requirements of an ordinary living room; but these are questions, although of the highest importance to every student, which must not now engage us. There are however purely æsthetic considerations connected with this subject of the admission of light, which are, it appears to me, perfectly fit to be entertained within these walls.

Very forcible effects are produced by mere contrast in the degree of light admitted. When an apartment is desired to be marked by a gay and festive character the eye should be prepared by subjecting it to a comparatively dim light. If, on the other hand, a solemn effect is to be aimed at, then advantage is gained by previously subjecting the eye to strong light. I have been frequently struck by the far greater effect of solemnity produced on the mind by entering a cathedral direct from the clear air of the cathedral close, than when entered from the cloisters, where the eye has already got somewhat accustomed to a subdued light. Indeed, for every great architectural scene it is well that the eye should be duly prepared.

I think that it may be broadly stated that a high light is, for almost every purpose of illumination, more pleasing than a low light. This is more especially the case when a grand and broad effect is aimed at.

By lifting the windows above the ordinary range of the eyes the intensity of the light is subdued, and a quiet effect produced. That sombre light which is so striking in the early Basilicas of Italy is due to the absence of lower lights in the aisles. No doubt much of the charm of those remarkable buildings is attributable to the unaffected purity and simplicity of form which distinguishes them from the theatrical straining at effect, the multiplicity of parts, and the flutter of architectural nick-nacks, which are apt to characterise later mediæval works.

Still this pleasing simplicity of form is very greatly enhanced by the light being admitted exclusively from the upper part of the building.

It might be easy to accumulate illustrations on this subject, but I will confine myself to one, and that of comparatively modern date, to show you that the principle which I urge on your attention is irrespective of style. At Milan, the ante-chapel of a church was built, probably in the sixteenth century, as a mausoleum for the family of the great Condottiere Trioulzi. There is little or no light below. At a considerable height from the pavement are deep recesses, within which the sarcophagi are placed, and over all is the clerestory. The whole light that this lofty and simple structure, with its mural sculpture, receives is from above, and the effect appeared to me to be extremely impressive. I may add that a very brief inscription on the walls, alluding to the active life of the great commander, was in excellent keeping with the repose of the scene: "Qui nunquam quievit, quiescit—tace!" (Be silent,—for he who never rested, rests!)

Besides the considerations that I have brought before you as requiring careful study when proportioning a window to its purpose, there is yet another very important one. The colour and texture of the walls must never be overlooked. It is most essential to take into account whether these vertical surfaces to be lighted are themselves light or dark in tone or colour; whether of a nature to absorb or reflect light; whether polished or rough. We all know practically when a room has to be lighted up artificially how much the requisite number of lights depends on these accidental circumstances. Observe the strongly diffused light produced by a single taper in a room with white walls, and compare it with the dim twilight obtained from the same light in a room papered with dark red paper. Of course the same holds good in daylight; and if we must have dark walls and furniture, it behoves us at the same time to have large windows.

You will perceive from these remarks how futile and empirical would be any rule for determining the proportion of solid to void in the external wall of a room. It is in truth experience derived from habitual unremitting observation that can alone safely guide us. "There are rooms"—says the great observer, Bacon—"where you cannot tell where to become to be out of the sun or cold,"—and this excess is doubtless a serious fault; but I believe generally that an excess of light is a less serious fault than a deficiency, for in the former case a variety of means readily present themselves of remedying the defect, while in the latter case the defect is irremediable.

I have now touched upon most of the more material subjects of inquiry in the interior disposition of a building. To consider the special arrangement of the several parts of a plan required for each of the various uses for which a building may be destined would be an endless task; nor would such special arrangements form a suitable inquiry within these walls, where, by the very constitution of the Academy, we are limited to that portion of our art which relates to æsthetics. For lessons in the theory and practice of construction you will have to seek elsewhere; nor shall I now enter at any length into the wide field of interior decoration, a subject which might well occupy us many evenings.

I will confine myself to the laying before you a few observations only on the general treatment of interiors. I am afraid that I venture an opinion much at variance with the general practice of many of our highest authorities, when I express my conviction that the introduction of a complete order into the interior of a building is a solecism and an indefensible inconsistency.

Digitized by Google

The entablature, as usually composed, is essentially a piece of external architecture. The frieze occupies the place of, and represents, the ends of the horizontal cross timbers of the roof or ceiling, and the cornice is but the overhanging extremity of the roof for the protection of the vertical face of the wall from the weather. To introduce such features within is irrational. The masters of the Greek art, so truthful in all they did, committed no such offence against propriety; nor do we find, as far as I know, any complete internal entablature (except in the cella of hypæthral temples, where of course they are perfectly legitimate) until our art had lost its youthful purity, and the original meaning of the component parts of the entablature had been lost sight of. Without going so far as to deny the applicability of these regular orders to the interior of great halls, or other large interior areas, they are at all events, I think, inapplicable to the ordinary purposes of interior designs, or in rooms of moderate capacity.

I am aware that this dogma carried out to its full limit would extend to the condemnation of labels over interior arches, inasmuch as they are but an over-hanging weathering or drip-stone; to the condemnation also of internal battlements and other features exclusively belonging to external architecture. Nor do I see how such can be defended, except on the ground that the practice of these solecisms prevailed during the most admired epochs of the art. At all events I would seriously counsel you to be on your guard against a too ready acquiescence in the practice of applying to the interior of buildings the forms and features of exterior architecture.

Before paper and paint had usurped their undivided dominion over the decorators of our apartments, our ancestors resorted to many means of internal mural decoration,—means, it may be, more costly, but certainly more tasteful, and more worthy of the character of art. Tyre supplied its rich drapery to embellish the walls of Roman buildings; and, following in the steps of Egypt, Assyria, and Greece, the artists of Rome loved to depict the fairest forms and most brilliant conceptions over the walls and vaulting of their apartments.

Inspired by the examples of eastern art, the founders of ecclesiastical architecture incrusted their walls with mosaics and painting. The looms of the east also enabled them to clothe their walls with the richest hangings,—rivalled afterwards by the weavers of France, of Flanders, and of England. But the general demand for economical decoration in latter times has created whole branches of mechanical manufacture to supply the place and mock the semblance of more durable, solid, and real enrichment. Costly hangings are represented by fabrics manufactured daily by the mile, and the most precious woods and rich marbles are reproduced by the simple process of the paint-brush and varnish-pot.

In the observations which I have addressed to you this evening I have referred to many existing examples of our art by way of illustration; but I have made those references with little regard to the special style of the examples. I do so because it is of far higher importance to study the principles of design rather than styles. Style is an accident in art; whilst principles, if they be sound, are permanent and universal.

The architectural style that has prevailed at any time or place will be found to be the involuntary result of a combination of circumstances: the political and social condition of a people; their degree of culture; their relations with other countries; and the materials for building which happen to be at their command. The fine arts in their destinies seem to have some analogy to the destinies of man himself. Each style of art has its infancy, its adolescence, its manhood, its decay. But there the analogy ends, —for man is continually reproducing in his children, and neither his physical nor his moral qualities are necessarily or generally deteriorated in the lapse of successive generations. But in architecture I fear it is a vain struggle to attempt to renew exactly any phase or state of existence that the art may have passed through. We may exactly reproduce a building—we may exactly repeat a form—we may mimic every feature; but I greatly doubt whether we can ever really and truly recall to life a style that has once passed away.

No observer of passing events during his own day; no one versed in the history and progress (if progress it be) of our art, can fail to see that, as it has had, so is it likely again to have vicissitudes in its fortunes, and that there are prevailing—perhaps cyclical and periodic—revolutions in popular architectural taste.

Contemporaneously with the revival of letters in the fifteenth century there was a resuscitation of the Classical styles. It gave birth at its outset to something very nearly approaching to an orginal, and therefore vigorous, style of building, which however fell ultimately into insipidity or extravagance. Within thirty years a like change has come over us. The film is supposed to have fallen from the eyes of a refined criticism, and we are busy in disinterring the relics, and detecting the beauty long latent in the free and fanciful chisellings of the fourteenth and earlier centuries.

I am addressing those who will live long enough to see another revolution in the wheel of architectural fortune. In the meanwhile, you who hope to lead must in some respects be content to follow; and all I can advise you to do is fairly to study and appreciate the merits of those several styles which have in their turn secured the favour of cultivated minds.

Make yourselves acquainted with their general principles, and apply to them the golden metre of your reason and good sense. I would venture to advise those of you to whom these lectures are especially adressed, to study diligently the venerable vestiges of bygone art in its best days, but study them in the free spirit of progress and advancement,—not of retrogression. Study principles, I repeat it, rather than styles; and in a painstaking, truth-loving spirit, work and hope. Utterly discard from your minds the bigotry of a mere antiquarian, and every tendency to uninquiring prepossession. Study the purposes and objects of art, and the lessons of nature. Study well the faults of our ancestors, as well as their beauties; but above all, let us not be content to rattle the dry bones of antiquity and fancy that it is music.

SMOKE CONSUMING BOILERS.

*Abridged from Reports of Inspectors to the Admiralty.**

Newcastle-on-Tyne, 19 August, 1858.

Sir,—In obedience to the orders of the Lords Commissioners of the Admiralty, dated the 1st of June 1858, directing us to proceed to Newcastle, to superintend and report on a repetition, or if requisite an extension, of a series of experiments upon the relative evaporative values of coal which has been instituted by the Steam Collieries Association of the North of England; and also to report on the merits of the plan proposed by Mr. Williams of Liverpool, and of the modifications introduced by the Association for Consuming the Smoke of Bituminous Coal when used in Tubular or other Marine Boilers,—We beg to state that we have performed this service.

The description of coal selected for the repetitional and comparative experiments with north-country coal, was to be obtained from the original West Hartley pits; and that for the comparative experiments with Welsh coal should be Powell's Dufferin; as the association in anticipation of our trials had obtained part of a cargo of this description of coal, which with other cargoes had been sent from Wales, for the purpose of coaling the Hudson, a large steam-ship built by Messrs. Palmer and Co. of Jarrow, for the German Lloyd's Company, for the purpose of navigating her to Bremen, and which is verified by the certificate attached to this report.

As our experiments proceeded, we considered it to be desirable that a comparison should be made with north-country coal and Welsh coal as supplied to the service; and therefore on the 3rd instant we wrote to their lordships, requesting that six tons of each description of coal should be forwarded to us for this purpose, and which were forwarded and received here from Woolwich Dockyard, and experimented upon.

We may here observe that the experimental boiler is a marine multitubular one. Upon this boiler, at the top of the uptake and the bottom of the chimney, is placed an oval vessel filled with tubes, through which the heated vapour from the boiler tubes passed before entering the chimney, and which may be called a water-heater, as all the feed-water to the boiler passed through this vessel. This heater is 5 ft. 4 in. in height, 5 ft. 8 in. in larger diameter, and 3 ft. 8 in. in smaller diameter; having 76 tubes 4 inches in diameter and 4 feet in length. The heating surface in the boiler being about 750 square feet, and that of the heater about 320 square feet.

All the experiments for the association having been made with the feed-water passing through the heater into the boiler as

* Ordered by the House of Commons to be printed, March 8, 1859.

Digitized by Google

before described, the whole of the experiments made by us, were made with this heater attached to the boiler and the feed-water passing from the supply tank through it into the boiler; but as this appendage is not common to boilers generally, we had it removed; and our concluding experiments have been made without it, the feed-water passing directly from the supply tank into the boiler, the results of which are contained in the following table.

During part of the experiments, the experimental boiler was fitted with Mr. Williams' apparatus for preventing smoke, which consists, in this case, of two hollow furnace fronts divided into three air chambers, and having a hollow fire door each, one chamber over the fire door with two apertures, one chamber at each side of the fire door with one aperture each, and the fire door, with two apertures in their exterior parts for the admission of air, and the whole of their interior parts perforated with small holes for the purpose of diffusing the air in streams amongst the gases arising from the burning coals; the area of the apertures and perforations being in the proportion of about 6 square inches for each square of fire-grate. The air passages of this apparatus were kept open when north-country coal was burnt without smoke, and closed when this coal was burnt to make smoke, and when Welsh coal was burnt.

During the experiments with north-country coal, the fires were kept from 12 to 14 inches in thickness, and the fresh coals at every firing were thrown alternately to the sides of the furnaces, so that at each firing one side of one furnace was charged at one time, and then after an interval the corresponding side of the other furnace was also charged; then, after another interval, the opposite side of the first furnace was charged, and then, after another interval, the opposite side of the second furnace was also charged; and so on, continuously, with the two furnaces. In every charge the coals were invariably thrown upon the fronts of the fires, and when requisite the incandescent fuel was pushed back at either sides of the furnaces towards the fire bridges, so that the gases arising from the fresh coals always passed over the hottest parts of the fires. This system of firing was also pursued in the two experiments when smoke was made, for the purpose of ascertaining the differences existing in the evaporative powers of this coal when preventing and not preventing smoke; thereby showing that this system of firing, although of great use when the air passages of Mr. Williams' apparatus were open, was of no material value when they were closed, for the smoke in these two instances was both dense and black.

It appeared from the experiments, that although the north-country coal, when burning the products that would otherwise make smoke, is slightly inferior in its evaporative powers in pounds of water per pound of coal, yet it is in some degree superior to Welsh in rapidity of combustion and evaporative velocity per foot of fire-grate, or, in other words, work done in a given time per foot of fire-grate; and therefore it has the advantage when a certain speed is to be obtained in a certain time without reference to economical considerations, the coals in both cases being supposed to be smokeless.

The experiments made with the long fire-grates, the fire-bars being 7 feet in length, and that one made on the 31st of July, very clearly showed the capabilities of Mr. Williams' apparatus for preventing smoke, when the system of firing before described was pursued for the prevention, was all but perfect. It may be here remarked, that the system of firing before described does not require more than ordinary attention on the part of the stoker, and gave no additional labour to the stoker employed throughout our experiments over that which he exerted when stoking with Welsh coals, the one system requiring no more practice than the other to make the stoker. The experiments made with Lambton's Wallsend house coals on the 27th of July, and also that made with the steam jet, are additional proofs of the efficacy of Mr. Williams' apparatus.

With reference to the advantage to be gained by the prevention of smoke in the saving of fuel, the experiments as compared with the average results of the north-country coal direct from the collieries, show a saving in pounds of coal for pounds of water; but they also show a nearly average rapidity of combustion and evaporation when the smoke is not prevented. Some of the experiments made after the water heater was removed, for the purpose of determining the difference of making or preventing smoke, also show that although this appendage to the boiler had some advantage in the evaporative powers of the fuel in pounds of water for pounds of coal, yet the rapidity of combustion and evaporation had been checked by it when north-country coal was burnt.

In further obedience to their lordships' orders, which direct us to report upon the modifications of Mr Williams' plan for consuming smoke introduced by the association, we inspected a modification of this apparatus, which consists of a furnace frame fitted with two fire-doors, the hinges of which are so placed that when the doors are opened they open back to back, the upper part and sides of the door frame being pierced with a number of holes, and the lower parts of the fire-doors having horizontal slits in them for the admission of air into the furnace. The object in having two fire-doors on one frame, opening in the way described, is to cause the stoker always to throw his coals to the sides of the furnace, instead of throwing them immediately into the middle of it, and of necessity forcing him to fire each side of the furnace alternately, and in the manner pursued in firing our experimental boiler. This modification of Mr. Williams' plan was fitted to three boilers which were in constant work, and the prevention of smoke appeared to be almost perfect.

We proceeded to the Bedlington Collieries, and there saw another modification of Mr. Williams' plan. In this the fire-doors are double, but open in the usual way; the fire-doors having horizontal slits in their lower parts, and the dead plate of the furnace being also made with slits in the centre part for the admission of air into the furnace. At these collieries there were four boilers fitted with this modification which were in constant use, and here also the prevention of smoke appeared as in the former apparatus to be almost perfect.

In the Expert steam-tug, the boilers, two in number with two furnaces each, are fitted with a modification of Mr. Williams' plan. This apparatus consists only of an ordinary furnace front fitted with one fire-door, which is perforated with a number of small holes in the lower part, and the dead plate of the furnace having an opening at each end and at the sides of the furnace for the admission of air into the furnace. As we were on board this vessel for several hours, we had every opportunity of seeing the effect of making and preventing smoke; and although there was no very careful stoking, yet the prevention was almost perfect.

From the average results of the experiments, and from our general observations, we came to the following conclusions:—

1. That when the smoke from north-country coal is consumed, its evaporative value is nearly equal to that of Welsh coal, while its rapidity of combustion is greater, and therefore that it is capable of generating a larger quantity of steam in a given time.

2. That from the harder nature of the north-country coal, it is less liable to be broken up from motion than Welsh coal, and from the large heaps which had been exposed at the pits' mouths for nearly twelve months, which we saw at some of the collieries, without exhibiting any symptoms of falling into small particles, thereby showing that atmospheric changes had but little effect upon it; and therefore, for these reasons, it is better adapted for store or conveyance to distant parts of the world than Welsh coal, which from daily experience is found, not only to be greatly reduced in size by motion, but to be reduced to dust when exposed to the changes of atmosphere in stores, &c. These comparisons are only made upon the supposition that the smoke from the north-country coal may be reduced to the same minimum as that which may arise from Welsh coal, or be entirely prevented by Mr. Williams' or some effective apparatus for this purpose.

3. That from our experiments at Elswick, and our observations elsewhere, it is possible to consume the smoke arising from north-country coal by the use of Mr. Williams' apparatus, and by the modifications of it as introduced by the association to some of the collieries in this part of the country, and also fitted on board the Expert steam-tug, and now being introduced generally into the steam-tugs of this port. For in the experimental boiler smoke was prevented when the firing was pushed to a greater extent than 30 lb. to the square foot of fire-grate; in one instance, on the 31st of July, the firing having been for one half-hour at the rate of 55½ lb. to the square foot, with but very light smoke, and for the next hour at the rate of 40 lb. per square foot without any smoke; and again on the 10th of August, when a steam jet was used to force the draught, the firing throughout the experiment was nearly 36 lb. to the square foot, the jet being produced by 20 lb. steam.

Digitized by Google

Experiments on Coal at Cardiff.

Woolwich Dockyard, 31 December, 1858.

Sir,—With reference to their lordships' order of the 7th December, and your instructions of the 8th, directing us to proceed to Cardiff to witness experiments on Welsh coal, also properly to inspect the boilers and furnaces, and to keep a careful record of the trials, reporting the results in a similar manner to the report recently made by Mr. Taplin and Mr. Miller of the trials of coal at Newcastle,—

We beg to report that we were conducted to a steam-vessel (the Isabella Croll) lying at her moorings in the Bute docks, having a boiler in which experiments on coal had been made previous to our arrival, of the same description as those which they intended to make in our presence on north-country (Hartley) and on Welsh coal (Aberdare). We found the boiler to be of the ordinary class used for marine purposes, in shape and proportions similar to those employed in Her Majesty's service. We found the furnace doors to be of the common description; but after the first four experiments were completed, and the quantity of smoke well tested, a modification of Mr. Williams' plan for the prevention of smoke was applied to them. A pyrometer, to register the temperature of escaping heat, was placed in the chimney immediately above the uptake.

It was interesting to witness how much the temperature of the escaping gas was affected as the stokers varied their mode of firing when the two descriptions of coal were used. This was strikingly apparent on the 16th December, when the Hartley coal was burnt and the fires were urged. The practice of using the whole of the cinders produced while the evaporation was progressing was adhered to here, as at Newcastle with the north-country and with Welsh coal. When large and small South Wales Aberdare coal were experimented on, the small coal was mixed with the cinders, and thrown on the fire in a mixed state, but they were used separately in experiments on Northumberland Hartley coal.

Williams' Apparatus for Consuming Smoke.

TABLE of average results from the Experiments with North-country and Welsh Coals, to compare the evaporative values of the two descriptions of coal.

Description of coal experimented upon.	Area of Fire-grate.	Results calculated from the latent heat of steam, being 966°, as taken by Messrs. Armstrong, Longridge, and Richardson, in their reports to the Steam Collieries Association of the North of England.				Results calculated from the latent heat of steam, being 988°, as adopted by the Admiralty in their reports of trials of coals.	
		Economic value on the evaporation from 212° by 1 lb of coal in lb of water.	Coal burnt per sq. foot of fire-grate per hour.	Rate of evaporation from 60° per sq. foot of fire-grate per hour.	Total evaporation from 60° per hour.	Water evaporated by 1 lb of coal, calculated from constant temperature of 100°.	Water evaporated per hour, calculated from constant temperature of 100°.
	Feet.	lb	lb	Cubic feet.	Cubic feet.	lb	Cubic feet.
North-country coal, West Hartley district...	22	11·05	26·21	3·82	84·08	10·39	87·16
North-country coal, and from Woolwich dockyard	22	10·97	23·61	3·38	74·35	9·84	77·06
Welsh coal, Powell's Dufferin	22	12·44	21·53	3·81	83·86	11·14	86·89
Welsh coal (Blaengwarn Merthyr) sent from Woolwich dockyard	22	11·98	20·36	3·33	73·15	10·39	75·85
North-country small	22	10·78	17·31	2·51	55·20	9·65	57·21
Welsh small	22	11·13	9·16	1·38	30·43	9·97	31·54
North-country coal	18	11·66	24·89	3·78	68·09	10·44	70·57
Welsh coal	18	11·08	24·12	3·71	66·72	9·93	69·11
North-country coal	22	9·75	29·53	3·94	86·63	8·73	89·87

REMARKS.—The whole of the experiments from which these averages, except the last, have been taken were made with the air-passages of Williams' apparatus open, and no smoke issuing from the top of the boiler chimney, excepting when Welsh coal was burnt, and then the air-passages were closed. The last of these experiments was made to observe the quantity of smoke issuing from the chimney-top, and also to ascertain the evaporative value of the coal when making smoke and when not making smoke.

The results of these experiments appear in the table subjoined, and the distinguishing features of each experiment will be found under the head "Remarks." After the first four experiments were made, and both descriptions of coal were tested, with the furnace doors of common form, it was determined to extend the experiments further by an altered furnace door, a modification of Williams' apparatus for the prevention of smoke. The tracing accompanying this report will convey an idea of this apparatus, specially provided for the three remaining experiments. We beg, however, to remark, that this apparatus was not made precisely on Williams' plan; the rule prescribed by Williams as to the ratio to be observed between the area of grate-bar surface and the perforations for air was nearly identical with that observed in these experiments; but there was a space left around the external edge of the inner plate, which prevented the formation of a close box, or air chamber, when the fire-door was shut. This open space admitted air in bulk, instead of in divisional streams. These deviations from Williams' rule, we are of opinion might have operated prejudicially in the experiments on north-country coal, inasmuch as more air was admitted than was due to the grate-bar surface, and not admitted through the most suitable part of the apparatus, nor in separate streams only, as suggested by the inventor; also the rectangular opening in the outer door was much less in area than it ought to have been.

The results of these experiments, as shown in the tabulated form, make it appear that while the coal from the South Wales collieries (Aberdare), is comparatively superior to the Northumberland Hartley, both in economic value and rate of evaporation, it is inferior in rate of combustion when burnt under the same conditions as to fire-bar surface and time; or in other words, the rate of combustion in pounds of coal burnt per square foot of fire-bar surface per hour is not so high with Aberdare as with Hartley coal.

As witnesses of these experiments, we had some doubts as to the dependence that might be placed on the feed apparatus for the boiler, with reference to the exact quantity actually entering the boiler as measured to the feed apparatus and registered by the meter. Priming of the boilers was evidenced in an especial manner on the first and second day's experiments; it was not constant, but intermittent. Owing to these circumstances, we cannot place so much dependence on the accuracy of the results of the experiments as could be wished.

REVIEW.

The Carpenter and Joiner's Assistant. London: Blackie & Son.

The favourable impressions conveyed by the appearance of the earlier parts of this work have been amply confirmed by that of the subsequent numbers; and if the price of issue be thought to range beyond the average in publications of the kind, so most assuredly does the quality of the contents, and the style of the getting up of the book generally. Of the twenty numbers in which it is proposed to embrace the subject, fourteen have now appeared,—all more or less valuable. In the last two will be found several well executed plates, illustrating the framing of trusses, circular and polygonal domes, bridges and centreings, joints in joinery, finishings of windows, hinging, and the construction of timber houses. Among the letterpress, the article

Digitized by Google

on the strength and strain of materials will be studied with interest, as also the tables of experimental results. We extract a portion treating of

Resistance to Tension.

"Although mechanically considered, this is the simplest strain to which a body can be subjected, it is yet the one in regard to which fewest experiments have been made, in consequence of the great force required to tear asunder lengthways pieces of timber of even small dimensions. There is too a want of agreement sufficiently baffling in the results obtained by different operators. The results of the experiments made by Muschenbroek, Buffon, Barlow, Bevan, and others, are given in the following table, reduced to a section of one inch square:

TABLE I.—*Tenacity of a square inch of different woods, expressed in the weight in pounds that will produce rupture.*

	Names of Experimentalists.							
	Muschenbroek.	Rondelet.	Morin.	Gayffair.	Barlow.	Bevan.	Emerson.	Mean results.
					12,000			
Oak, English	17,300	13,950	17,600	9,187	8,889	19,800	7,850	13,316
Elm	13,489	...	14,788	14,227	...	14,400	6,070	14,226
Beech	17,300	...	11,376	11,461	11,467	22,000	...	14,720
Ash	12,000	...	17,064	12,406	17,207	...	...	14,670
Chesnut, Spanish	...	13,300	...	...	...	10,500	...	11,900
Sycamore	...	...	...	...	...	13,000	5,000	13,000
Poplar	5,618	...	5,260	...	...	7,200	...	6,016
Alder	14,186	...	...	...	...	...	4,290	14,186
Acacia	20,582	...	...	...	...	16,000	...	18,291
Walnut	8,130	...	...	...	...	7,800	5,360	8,465
Mahogany	...	...	...	8,912	8,000	21,000	...	18,950
						Old.		
Teak	...	...	15,642	12,922	15,090	8,200	...	12,460
Aspin	...	...	6,990	...	...	...	...	6,990
Lance-wood	...	...	...	...	...	23,400	...	23,400
Box	...	...	19,908	19,880	19,890	...	...	19,892
Pear	...	...	9,900	...	9,822	...	...	9,861
Larch	...	10,220	...	...	...	8,900	...	9,560
Riga fir	...	...	...	...	12,253	13,300	...	12,776
Petersburg	...	...	...	...	...	13,300	...	13,300
Fir	8,506	...	...	...	...	...	5,000	7,818
Pitch pine	7,858	...	...	...	...	...	...	7,818
Cedar	4,973	...	...	...	...	11,400	...	8,186
Norway pine	...	7,287	...	...	...	14,300	...	10,293
Birch	...	...	...	...	...	...	15000	15,000
Hawthorn	...	...	...	...	...	10,500	...	10,500
Hazel	...	...	...	...	...	18,000	...	18,000
Holly	...	..	...	...	...	16,000	...	16,000
Hornbeam	...	...	...	...	...	20,240	...	20,240
Laburnum	...	...	..	...	...	10,500	...	10,500
Lignum-vitæ	11,800	...	...	...	...	...	...	11,800
Lime-tree	...	...	...	...	...	23,500	...	23,500
Maple	...	...	...	...	...	10,584	...	10,584
Plane	...	...	..	...	...	11,700	...	11,700
Willow	...	...	...	...	...	14,000	...	14,000
Spanish yew	...	...	...	...	...	8,000	...	8,000

Although on many considerations it is not to be expected that experiments made on such small scantlings of timber as were used by the experimentalists above cited (some of these being only a square line in section), would agree with each other; yet the discrepancy is so great as to give little confidence in the results. Mr. Barlow, on mature consideration, has given the following table of the tenacity of wood usually employed by the carpenter; and subjoined is the mean result from the foregoing table, for the sake of contrast:

TABLE II.—*Tenacity of a square inch of timber in pounds.*

	Barlow's mean results.	Mean results of Table I.
Oak	10,000	13,316
Ash	17,000	14,670
Beech	11,500	14,720
Teak	15,000	12,460
Mahogany ...	8.000	18.950
Riga fir	12,000	12,776

As Mr. Barlow's experiments were very carefully conducted, his table may be assumed as a safe guide.

As the strength of cohesion must be proportional to the number of fibres of the wood, or in other words to the area of the section, it follows that the tenacity of any piece of timber, or the weight which will tear it asunder lengthways, will be found by multiplying the number of square inches in its section by the tabular number corresponding to the kind of timber."

Resistance of Timber to Compression in the direction of the Length of its Fibres.

"Experiments on this kind of resistance are not numerous.

Mr. Rennie found that to crush a cube of 1 inch on the side, the weights in lbs. required were, for—

African oak	6720 lb.
English oak	3860 ,,
White deal	1928 ,,
American pine	1606 ,,
Elm	1284 ,,

M. Rondelet obtained higher results; that is the timber experimented on by him presented a greater resistance. According to this author, a piece of timber diminishes in strength as it begins to bend; so that the mean strength of the wood of the oak, which is 44 lb. French for every line superficial in the case of a cube, is reduced to 2 lb. for a piece of the same wood when its height is 72 times its base. From a great number of experiments he compiled the following progression:

In a cube the height of which is	1,	the strength is	1·	
In a piece,	,,	,,	12,	,, ·833
,,	,,	,,	24,	,, ·5
,,	,,	,,	36,	,, ·33
,,	,,	,,	48,	,, ·166
,,	,,	,,	60,	,, ·083
,,	,,	,,	72,	,, ·041

Thus, in a cube of oak of 1 inch superficial of base, submitted to the action of a force pressing vertically, the mean force is expressed by 144×44=6336	While the mean of experiments gave	6346
In a bar of the same wood of the same base, and 12 inches high, the strength by the progression would be 144×44×·833=5278	,,	5310
In a bar 24 inches high, the strength by the formula 144×44×·5=3168	,,	2911
In a bar 36 inches the strength by the formula 144×44×·333=2110	,,	2163

In a bar 48=144×44×·134=849.
In a bar 60=144×44×·083=526.
In a bar 72=144×44×·042=266.

In fir bars the following results were obtained:

	By calculation.	By experiment.
In the cube of 1 inch, 144×52×1·	=7488	7490
In the bar of 12 inches ,,	×·833=6238	6355
,, 24 ,,	,, ×·5 =3744	3429
,, 36 ,,	,, ×·33 =2471	2575

These results, M. Rondelet observes, accord with the experiments of MM. Perronnet, Lamblardie, and Girard.

In an experiment described by the latter, a piece of wood 2 metres 273 millemetres long, and 155 by 104 millemetres in section, broke under a weight of 33,120 kilogrammes.

Reducing these into English measures, the length is 7·35 feet, the sides of the base 6·05 and 4·06 inches respectively. The area of the section is therefore 24·5 inches, and as the weight is 72,864 lb., the weight on the square inch is 2974 lb.

The height of the piece is about twenty-two times the size of its base and the progression would give a reduction of half the strength. If therefore 2974 is doubled, 5948 lb. are obtained as the absolute resistance per square inch,—a result which agrees very closely with the experiments of M. Rondelet.

The same author arrived at the following conclusions:—

1. That the resistance does not sensibly diminish in a prism, the height of which does not exceed eight times its base.

2. That when the height of the prism is ten times its base it begins to yield by bending.

3. That when the height is 16 times the base, the piece of wood is incapable of resistance.

Tredgold says that when the length of the wood is less than eight times its diameter, the force causes it to expand in the middle of its length, and split into several pieces, but when it exceeds this length it yields by bending. In practice the last case is almost the only one which occurs."

The following table (p. 124) of the properties of timber will be found comprehensive and useful.

The subject of practical carpentry as applied to Roofs is as yet scarcely entered upon; we shall therefore reserve any observations on this topic till the essay is complete.

Digitized by Google

Table of the Properties of Timber.

	Specific gravity, water being 1·0.	Weight of a foot, dry, in lbs.	Weight of a bar, 1 foot long, 1 inch sq., in lbs.	Absolute tenacity of a sq. inch. Average in lbs.	Tenacity of a sq. inch without injury, in lbs.	Modulus of elasticity, in lbs.	Modulus of elasticity, in feet.	Crushing force per sq. inch, in lbs.	Constants for posts, and value of c.	Tredgold's formulæ.		Barlow's formulæ.	
										Value of a.	Value of C.	Value of S.	Value of E.
Acacia	·710	44·37	·30	18,290	...	1,152,000	373,900	...	...	...	·621	·1867	
Alder	·800	50·	·347	14,186	...	...	...	6,895					
Apple-tree	·793	49·56	·344	19,500									
Ash	·690	43·12	...	...	...	...	...	...	·00168	·0105	·677	·2036	·244
	·845	53·81	...	17,207	3,540	1,644,800	4,970,000	8,683					
	·760	47·5	·33	...	...	1,640,000	...	9,363					
Bay-tree	·822	51·37	·35	12,396	...	...	...	7,158					
Beech	·690 to ·854	43· 53·37	... ·315	.. 14,720	... 2,360	... 1,353,600	... 4,600,000	7,733 9,363	·00195	·0127	·552	·1556	·195
Birch	·792	49·5	·34	15,000	...	...	5,406,000	6,402	...	·0141	·643	·1881	·240
„ American	·648	40·5	·28	11,663	...	1,257,600	3,388,000	11,663	...	...	·605	·1834	·256
Box	·960	60·	·41	19,891									
Bullet-tree	1·029	64·31	·446	...	...	2,601,600	5,878,000	...	...	...	·882	·2646	
Cane	·400	25·	·174	6,300									
Cedar, new	·909	...	...	10,293	...	...	...	5,674					
„ „ seasoned	·753	47·06	·32	...	...	...	...	4,912					
Chesnut	·657	41·06	·285	11,900	...	...	...	...	...	·0187			
Crab-tree	·765	47·81	·33	...	...	...	...	7,148 6,499					
Deal—													
Christiania	·693	43·62	·30	12,400	...	1,672,000	5,378,000	6,586	...	·0095	·521	·1562	·230–·115
Memel	·590	36·87	·25	...	...	1,536,200	6,268,000	...	...	·0089	·577	·1731	·190
Norway spruce	·340	21·25	·147	17,600	...	...	...	7,293	·00142				
English spruce	·470	29·37	·20	7,000	...	...	...	...	...	·0124			
Elder	·695	43·43	·30	10,230	...	...	...	9,973 8,467					
Elm	·544	34·	·236	...	3,240	1,340,000	5,680,000	...	·00184	·017	·372	·1115	·101
	·588	36·75	...	13,489	...	699,840	...	10,331					
Fir, Riga	·753	47·06	·32	11,549	...	1,328,800	4,080,000	5,748	·00152	·00115	·369	·1108	·167
				12,776	...	869,600	...	6,819					
„ Mar	·693	43·31	·30	12,000	...	...	2,797,000	...	...	·0233	·380	·1144	·94
Hawthorn	·91	38·12	·26	10,500									
Hazel	·86	53·75	·36	18,000									
Holly	·76	47·5	·32	16,000									
Hornbeam	·76	47·5	·32	20,240	...	...	...	7,289					
Laburnum	·92	57·50	·40	10,500									
Lance	1·022	63·87	·44	23,400									
Larch	·522	32·62	...	10,220	...	10,740,000	4,415,000	5,568	·0019	·0128	·284	·853	·120
	·560	35·	·243	8,900	2,065	1,052,800	...	...					
Lignum-vitæ	1·22	76·25	·53	11,800									
Lime-tree	·760	47·50	·32	23,500	...	...	...	...	...	·0152			
Mahogany—													
Spanish	·800	50·	·34	16,500	...	...	...	8,198	·00205	·0137			
Honduras	·560	35·	·243	18,950	3,800	1,596,300	6,570,000	...	·00161	·0109			
Maple	·793	49·56	...	10,584	...	...	...	...	...	·0197			
Oak, English	·830	52·	·36	...	3,960	1,700,000	4,730,000	4,684	·0015	·1024	·553	·1658	·210
	·934	58·37	...	13,316	...	1,451,220	...	9,509 10,058					
„ Canadian	·872	54·50	·378	10,253	...	2,148,800	5,674,000	4,231 9,509	...	·009	·588	·1766	·310
„ Dantzic	·756	47·24	·327	12,780	...	1,191,200	3,607,000	7,731	...	·0087	·560	·1457	·149
„ Adriatic	·993	62·06	·43	...	...	974,400	2,257,000	...	...	...	·526	·1383	
„ African	·972	60·75	·42	...	...	2,282,300	5,583,000						
Pear-tree	·661	41·31	·283	9,861	...	...	...	7,518	...	·0215			
Pine—													
Pitch	·660	41·25	·283	7,818	...	1,225,600	4,364,000	6,790 5,445	...	·0166	·544	·1632	·177
Red	·607	41·06	·26	10,000	...	1,840,000	6,423,000	5,375 7,518	...	·0109	·447	·1341	·272
American yellow	·461	28·81	·20	...	3,900	1,600,000	8,700,000	5,445	...	·0112			
Plane-tree	·640	40·	·28	11,700	...	...	...	...	...	·0128			
Plum-tree	·786	49·06	·338	11,351	...	...	...	10,493 9,367 3,657, wet.					
Poplar	·383	23·93	·164	6,016	...	...	...	3,107 5,124	...	·0224			
Sycamore	·69	43·1	·296	13,000	...	...	...	...	...	·0168			
Teak	·657	41·06	·282	12,460	...	2,414,400	7,417,000	12,101	·00118	·0076	·820	·2462	·349
Walnut	·671	41·93	·288	8,465	...	...	...	7,227	...	·020			
Willow	·390	24·37	·167	14,000	...	...	...	6,128	...	·031			
Yew, Spanish	·807	50·43	·347	8,000									

Digitized by Google

ON THE ARCHITECTURE OF THE THIRTEENTH CENTURY.*

By GEORGE GILBERT SCOTT, A.R.A.

IN my last lecture I gave a hasty outline of the developed architecture of this great period. I will now endeavour to give an equally hasty glance at some of its more marked creations, beginning—as in duty bound—at home. Their number however is so great, that one is perplexed to know where to begin, or in what order to take them. Perhaps the most profitable way will be to imagine the student to live in London, and to commence with the works of this century which he may study within a walk of his home.

To begin then with the church of St. Saviour, formerly St. Mary Overie—in Southwark. When I first knew this church the whole of it was standing: externally, it is true, the aspect it presented was not very pleasing, for it had been cased almost throughout with red brick, and the Lady Chapel was little else than a ruin. The choir was then in course of restoration. The interior was a most noble structure, and was almost perfect, and nearly all of this century, though some small portions westward were earlier, and the south transept possibly a little later. The whole was on a very symmetrical design, that of the nave being very much on the same with the choir. Its character may easily be judged of from what remains. It was nobly massive and grand, not of lofty proportions, but still such as to satisfy the eye. The pillars were alternately round and canted squares, flanked with attached shafts; the triforium consisting of arcades, interrupted only by the vaulting shafts. At the east end is a beautiful Lady Chapel, vaulted on light clustered pillars. The restoration of the choir was carried out by the late Mr. George Gwilt, aided by his sons; and it is impossible too warmly to praise the zeal and ardour with which they pursued the work, their study of the style then so little understood, or the untiring pains they took to render their restoration accurate. All these ardent lovers of ancient art are now deceased, and I feel a melancholy pleasure in bearing witness to their merits. I was intimately acquainted with one of the sons, and never did I meet a man more enthusiastically devoted to the style on which his artistic education had been founded. He absolutely adored everything which was Early English; and in carrying out restorations—in one of which he aided me—so faithfully did he reproduce the whole work, that nothing could induce him to alter even the positions of the jointing of the ashlar work. The pains which Mr. Gwilt took in restoring the choir disgusted the heartless parishioners, who, on proceeding to the transepts, placed the work in other hands; but on the Lady Chapel being undertaken by private individuals, Mr. Gwilt nobly undertook the work gratuitously, and carried it out with the same care he had bestowed on the choir. Shortly after this a report having arisen that the nave roof was decayed, a surveyor was employed to examine it; who, recklessly condemning it as unsafe, it was taken off, and none put on in its place. The walls, being of chalk, became shattered by exposure to the frost of several winters; and when the restoration of the nave was proposed to the parishioners, that enlightened body of men negatived it, and, taking down the glorious old structure, erected the present monstrosity in its place. Happily however the interiors of the choir and Lady Chapel are still perfect. Let us hope and pray that their widowhood may not be of much longer duration, but that a reproduction of the noble nave may be substituted for its unworthy supplanter. I should mention that the nave was entered on the south side by a very noble double doorway, of great height and depth, though when I knew it its decorative features had perished. I will only add that if measured drawings of this church are in possession of the family of Mr. Gwilt, it would be most desirable that they should be deposited among public archives, to await the time when they must be wanted as a guide to the re-erection of the lost portions. In the mean time, let me beg of you to study well what remains.

NEXT in importance, and probably in date, comes the choir of the Temple Church, which was consecrated in 1240,—a more fortunate building than the last, and not needing from me any chronicle of its restoration. It is in idea a magnified transcript of the Lady Chapel of St. Saviour's, being, like it, vaulted throughout upon pillars of equal height, and is probably about the most perfect specimen in England of this beautiful mode of construction.

The only other important instance I recollect in London of the earlier portion of our style is the chapel at Lambeth,—a very good Early English chapel, though somewhat dishonoured by plaster vaulting, the ribs of which I myself saw being prepared for by a core of spikes and tar cord. Let us hope that this is the last instance of such construction, especially of its introduction in a time-honoured building like this.

We now come to one of the noblest of England's temples,—the Abbey Church of Westminster; and you will readily excuse me from dishonouring this truly glorious temple by attempting its description in the course of a hasty catalogue like what I am now giving. As you all know, it was commenced in 1245 by King Henry III., and the eastern portions finished about 1269. This makes it contemporary, in a certain sense, with Amiens; for though the latter was commenced in 1220, it was not completed till 1288. There can be no doubt that the cathedral at Amiens was, at the time of its erection, viewed as the most perfect development of the style; for it is clear that it was made in many instances the model on which the designs of other churches were formed. Cologne Cathedral, for instance, was commenced in 1248, during the erection of that at Amiens, and is manifestly a free copy of it so far as concerns its earlier portions; and though Westminster Abbey is by no means built on the model of Amiens, it was probably influenced by it. That prodigious pile, carried forward through so long a series of years, would be a great object of interest to all contemporary church builders; and Henry, who was much in France, would naturally send the architect of his own sacred mausoleum to see the great work of his day. Westminster Abbey is a church built on a French ideal, but with English detail,—a great French thought expressed in excellent English. The windows are of the perfected bar tracery, which had not yet been much used in England; but in other respects I cannot find a distinctively French detail—or scarcely any—in the building, excepting the work of a single French foliage carver. Even the plan, which is purely French in idea, is carried out in a manner quite different from that of any French church I have seen.

In the architecture the union of the manners of the two nations is most happy. The pillars are nearly like those of the great French cathedral, but the side shafts, instead of being attached, are separate shafts of Purbeck marble, the nucleus and the capitals and bases being all of the same beautiful material. The use of this hard stone led to that of moulded unfoliated capitals, in which they lose in effect when compared with those at Amiens; but the nobler material would more than compensate for this.

The triforium is far superior to that at Amiens, both in design and detail, and the whole internal design, though inferior in size and altitude, is to my eye far more pleasing; and when its varied materials retained their colour, and the Purbeck marble, which pervades every part, preserved its polish, there cannot be a doubt as to the superior magnificence of its effect. The parts too are much better proportioned, with perhaps the one exception of the too acute form of the main arches; the wall arcading is much more beautiful, and the details generally more richly moulded. We have then here, at our doors, a building whose interior is equal to that of any existing Gothic building, and we have no excuse if we do not avail ourselves of so noble an opportunity of study. Of the exterior I will say nothing. All its old features had perished by the end of the seventeenth century, when they were vilely renewed, and this base restoration is now in its turn decayed.

The Chapter-house is a splendid but melancholy relic, little more than a ruin, and that not like those ruins which seem to do honour to the memory of their bygone glory by the picturesque loveliness which graces their decay. It is choked up with presses, chests, galleries, huge sacks of parchment, and every possible obstruction and disfigurement. Its beautiful windows—which filled the entire width of its sides—walled up, and its elegant vaulting destroyed. Just enough remains to render its restoration practicable. I have with great labour traced out all the old details, and only wish for the chance of restoring it in some degree to its pristine beauty. I exhibit a drawing of it as restored. I should mention that the splendid encaustic floor is still perfect, and that very fine specimens of wall panelling still remain. The vestibule and staircase by which it is approached are beautifully designed, and the doorway from the cloister is among the most splendid relics of English art. The latter is in a dreadful state of decay, but I am happy to say that it has just been stereotyped in its present state by the application of an invisible solution, which

* Lecture delivered at the Royal Academy.

Digitized by Google

will prevent the further progress of disintegration, and which has set and hardened the crumbling particles, which the gentlest touch would have before displaced.

The foliated carving in Westminster Abbey unites the two great types which characterise this century—the conventional and the natural,—and contain some of the best of each. I commend it to your careful study, and will mention that all within reach has been indurated in the manner I have just alluded to. What remains of the figure-sculpture is also of great merit, especially four angelic figures in the triforium of the transept, and two full-length figures in the Chapter-house, one of which I had the great happiness of discovering.

The internal proportions of the Abbey seem to me to surpass those of any other I have seen. They appear to be generally founded upon the equilateral triangle, and a comparison of this with many other churches will confirm the truth of what I have heard has been stated by an ancient freemason,—that the square will furnish good proportions, but the equilateral triangle much better.

The introduction of Italian mosaic work—both porphyry mosaic on the pavement, and glass mosaic on the tombs of the builder and rebuilder of the Abbey—is a fact of great interest, as showing the high estimation in which the arts peculiar to Italy were then held, so much so as to lead to the bringing to England of two master mosaic workers—Odorico and Pietro (each no doubt with his staff of workmen)—to carry out the two branches of the art. Both artists were from Rome, as the inscriptions still testify; but their work was put together here, as is proved by the use of Purbeck marble, both as the groundwork of the pavement and for the architecture of the tombs. This architecture is not very elegant in its details, excepting only the beautiful spiral pillars and some of the surface patterns prepared for the mosaic; and the introduction of art so inferior to their own for the sake of the rich inlaying it contained, still more strongly proves their appreciation of the merits of the mosaic art. Let us follow the example more wisely, and when we import any foreign speciality, let us not bring with it any of the demerits which chance to accompany it, but unite it with the best art we are masters of.

I know few, if any, churches which possess the same internal beauty as Westminster Abbey. More modern art has done its worst to ruin it, but its intrinsic loveliness overrides every such attempt, and reigns triumphant over every disfigurement. One characteristic it possesses almost alone,—I mean the virgin privilege of perpetual exemption from the brush of the whitewasher. It probably owes this unique happiness to its having been built on the principles of constructive polychromy. It has materials of at least four varieties of colour, and these in some degree systematically and artistically used; and this fact has been sufficient to keep the whitewasher at bay. We are told that it is un-English and fantastic to care anything about the colours of our materials; but let it never be forgotten that the churches which could boast of the chaste dignity of their unvaried stone colour, have been both at home and abroad made over periodically to the tender mercies of the monochromist, while this at least has been spared, —and that on account of the un-English phantasy of using more than one natural colour in its construction. These colours are now nearly concealed by smoke, but they still show modestly through, and still aid in rendering the tone more solemn and striking than that of any church I have seen, excepting that very different one, St. Mark's,—at Venice.

Among the monuments in the Abbey belonging to this century I will mention—in addition to the Italian works already alluded to—the effigy of William de Valence, an oak figure plated with enamelled copper, the enamels on which are of magnificent workmanship;—the beautiful bronze effigies of Henry III. and Queen Eleanor, with the marble altar-tomb on the latter, and its beautiful iron grille;—the pretty little altar-tombs of some of the royal children,—and the gorgeous monuments to Edmund, Earl of Lancaster, and Aveline, his countess; the latter have been among the most splendidly decorated works of their day, and are worthy of the very closest study, both by the architect and the architectural painter.

I will call attention to one other object in the Abbey,—I mean the remarkable ancient retable, or moveable reredos, formerly belonging to the high altar. It is a wonderful work of art, and I call attention to it especially in this place, because it contains the most beautiful specimen of very early painting remaining in this country. It is probably by an Italian artist, several of whom are known to have been brought over about this time; but I confess I have seen no work of its age in Italy which I thought equal to it,—an opinion confirmed by an Italian professor of architecture to whom I once showed it. It is, I believe, contemporary with the early days of Giotto.

I will now pass on to a far humbler building, and one very little known or visited; I mean the Chapel of St. Ethelreda in Ely-place, Holborn. This was the chapel of the splendid town palace of the Bishops of Ely, and was built by Bishop De Luda soon after 1290. The destruction of the palace you will, I dare say, recollect to have been celebrated by Pugin in his 'Contrasts.' It was sold during the last century, and the present untempting looking street built on its site,—a place where one would as little expect to find a gem of ancient art as the ripe strawberries which Dickon of Gloucester saw growing there and begged for.

The chapel is in a wretched plight; its side windows have lost both tracery and mullions,—its west window is in a great measure boarded up,—the cradled roof plastered,—the whole galleried around and fitted up with pewing which would disgrace a tabernacle of the last century;—yet through all this its beauty still shows. The chapel is, as was so usual with private chapels, elevated on an overground crypt, so as to bring it to a level with the principal apartments of the palace. Curiously enough, this crypt is not vaulted, but has over it the original floor, of massive timber.

The east and west windows, of five lights each, are among the finest of their period and size. The side windows, denuded of their tracery, retain internally their beautiful jamb mouldings, and the wall between them has a graceful canopied and crocketed panel to each intervening pier, which gives the sides a very rich effect. I had longed and often lamented their mutilated condition, and was one day trying to get at some clue to the design of their tracery, by examining the scars where it had been amputated, when the thought struck me that the two westernmost of them being blocked up by the adjoining houses, might, if opened out, be found to retain their decorative features. I applied for permission to do this; and what was my delight, on removing the material which obstructed them, to find the old window—mutilated indeed, and shattered,—but still retaining every element needful to the restoration of its design!

The doorway to the chapel is very beautiful, and its foliated ornament well worthy of study. The internal dimensions are about 90 feet by 30,—a favourite size it would seem, and not differing much from the dimensions of St. Stephen's Chapel, that at Temple Balsal, or the Sainte Chapelle at Paris (reckoning the latter in French feet).

The architecture of the chapel is nearly allied to that of a series of sepulchral monuments I alluded to in my former lecture, and some of them again in this. One of these is that of its own founder at Ely; the second and third are those of Edmund and Aveline, Westminster Abbey, and the fourth is that of Archbishop Peckham, at Canterbury. All these date between 1290 and 1300, and are works of exquisite beauty and of the richest decorative art.

I will now lead you on a short excursion out of London, to a glorious old temple, which was in the days of my pupilage considered to be within walking distance, and can now be reached in less than an hour by railway. I mean the venerable Abbey Church of St. Alban.

You probably know the general history of this church: founded over the tomb of the Protomartyr of England, and within ten years of his martyrdom, and rebuilt on a larger scale by Offa, king of Mercia; it was again rebuilt of its present enormous dimensions by the earlier of the Norman abbots, using the materials excavated from the ruined city of Verulam.

The Roman brick was not a material very suggestive of ornamental architecture, and we accordingly find the original portions to be plain and massive in the extreme, but nevertheless highly impressive and interesting. In the work of the later Norman abbot we find this unshapely material cased with stonework, and of richly decorative details; but the church in general retained its severe simplicity undisturbed till the accession of Abbot John de Cella, in the reign of King John.

This worthy abbot was more a man of taste than of business, and his temperament more sanguine than calculating. He had no sooner taken possession of the abbacy than he embarked on a magnificent project for rebuilding the western façade of his abbey,—only a prelude probably to the reconstruction of the whole in the new style.

Digitized by Google

The massive brick front, with its flanking towers, would have formed an excellent nucleus for his work, but his ardent spirit would not submit to such an expedient, and he at once took down the vast façade, and that before he had collected money for the new one. The consequence was that he had scarcely got his new work out of the ground before his funds were exhausted. His first builder turned out a rascal, and he had to discharge him; the stone he used was destroyed by the frost; and mishap after mishap following his undertaking, the worthy man was led, as is so common with bad men of business, to bend his proud spirit to a paltry trick, and, as a means of raising the wind, he sent one of his monks about the country with a man whom he declared to have been raised from the dead by the agency of the relics of St. Alban, and begged money on the strength of the miracle; but all would not do, and after ten years' labour, during which the old historian tells us that all the funds he procured were merely like rivers flowing into the sea, which was no fuller for receiving them, he could not bring his work above the level of the masons' shed; and at length, giving it up in despair, contented himself with more humble undertakings.

He was succeeded by Abbot William de Trumpington, a man who united with the taste for building inherent in the age, a more moderate ambition and greater aptitude for business. He resumed the suspended works, but moderated their costliness; and making all the details plainer, and giving up or postponing the flanking towers, he was not only enabled to complete the rest of the front, but also to carry on the new work a long way down the nave, and subsequently to make many other alterations.

Now, I beg you to go and examine these works, and in doing so to bear in mind their history. You will find—as the chronicler tells us—that just about the height of a mason's shed there is a sudden change in the work. Up to that height the details are very superior, and far richer than above. Below we find traces of the artist,—above, of the constructor and man of business, though not to the forgetting of art. Thus, round the piers below are bases for marble shafts; somewhat higher are the marks where their moulded bands have been broken off; but above their capitals are wanting,—

"For William's shears had cut the bauble off."

The three portals I alluded to in my last lecture are the work of the unfinancial artist; the range of pillars, &c., down the nave of the not inartistic man of business. Both are noble works: Trumpington's works are bold and massive, and his details good, though simple; but, for beauty of design, we must award the palm to his less thrifty but more *spirituel* predecessor: indeed I know few works equal in design to what he commenced, and had he been able to carry it out, this façade might have vied with that of Wells. Unhappily there are externally little remains of the work of either of the abbots. Late in the century the choir also was in great measure rebuilt. Its character is less forcible than the earlier works, yet exceedingly beautiful.

The eastern chapels—which opened by five arches into the church—were at the same time commenced, but only in part carried out,—the Lady Chapel having been stopped short after rising a few feet from the ground, and the chapels which opened from the choir, having suffered considerable alterations from their first design. They are now virtually in ruins, but their details are of exquisite beauty. The windows have tracery of very high merit, and the wall arcading—now almost entirely destroyed—has been quite charming.

These works form a continuous series, from the last days of the twelfth to the end of the thirteenth century, and are admirable illustrations of the architecture of this great period.

I will dip seven years into the succeeding century to mention the exquisite fragments of the substructure which carried the shrine of the protomartyr. They have recently been exhumed in opening a walled-up arch. They are of Purbeck marble, and, in spite of the stubborn material, are most wonderfully carved, the leaves being so much undercut as in places to be quite detached.

This venerable church possesses claims upon the student residing in London, second only to those of our own Abbey of Westminster. I recommend it to your special and diligent study, and you will I am sure never blame me for my advice.

On some of your visits there, pray go on to Dunstable, where you will find a noble priory church in the later Norman style, whose western portal was probably in its day the finest in the kingdom; but, owing to the friable clunch of which it was constructed, has lost the greater part of its decorations. The west front contains excellent work of the thirteenth century. It is a great architectural enigma, which I believe I have solved, but I will not spoil it for you by explaining my conjectures.

I begin to see however that I have embarked on an endless task and have got half through my time without getting through the home district. I will therefore leave it, with a request that you will not consider Stonechurch, near Gravesend, the worse for having become somewhat hackneyed. It is a mutilated work, but what remains of it is as exquisite an example of a period about agreeing with that of Westminster Abbey, as can perhaps anywhere be found.

As I cannot pretend to give you a complete architectural itinerary, I will imagine—not seeing my way to a better—a northern tour in search of works of the age I have been treating of, and giving a passing look at Waltham Cross, in which I once delighted—though now I confess its so-called restoration has rather damped my enthusiasm—and hastily looking in at Jesus Chapel at Cambridge, a very excellent specimen of Early English, let us proceed to Ely. I have repeatedly alluded to the two great works in our style which it contains: the western porch, built between 1197 and 1214, is by far the noblest in this country. It is peculiar in its size and position,—more of a narthex perhaps than a porch, or rather the western arm of the cross formed by the western transept. Externally it is covered with decorative arcading in four ranges. It is of two stories, the upper one having formed a spacious chamber. The angle buttresses are of that beautiful kind which are almost peculiar to this period, being of the form of clustered pillars.

The two portals—the outer and the inner—are, in their leading forms, alike: they are double, and of very lofty proportions. Their heads were formerly filled with the Vesica Piscis, probably containing sitting statues; but this—why, it is impossible to divine—was taken out in both instances, and a wretched piece of flowing tracery substituted by Bernasconi, to the no small detriment of the doorways. The inner doorway is an exquisite work of art, the mouldings being most beautifully foliated. The sides of the porch are arcaded in two stages in a most beautiful and artistic manner, and probably contained sculpture. The capitals are among the finest to be found in any English building. The porch measures internally 40 feet by 30 feet.

The other great work of this century, at Ely, consists of the six eastern bays, with the eastern front. They were commenced by Bishop Northwold in 1235, and completed in 1251. It forms one of the finest specimens of the Early English style. The noble development of its triforium is an inheritance from the Norman church, with whose levels it was made to range. The liberal use of Purbeck marble adds vastly to the beauty of the work; the pillars are entirely of this material, including even these richly-foliated capitals, as are the long and elaborately-carved corbels which carry the vaulting shaft. The carrying out of the whole—its proportions, its details, its mouldings, the massive strength of its construction, united with just a sufficient degree of lightness, the great elegance of its vaulting, and the grandeur of its eastern façade—render it one of the most valuable objects of study which we possess. The tomb of its founder is a wonderful work of art,—a canopied effigy surrounded by statuettes, angels, and even subjects, all in a single block of Purbeck marble.

There are other works of our period at Ely, and fine ones; but we must not linger there, but proceed onward to Peterborough. If the three great arches which form the west front here are to be viewed as portals, I was certainly wrong when I said that English portals were small and inconspicuous. These are in fact of such vast elevation as to deprive them of that title. The whole may be viewed as a vast portico it is true, but the doorways are within it, and of moderate dimensions, while above them, and still below the arches, are considerable windows. It is in fact a design which stands quite by itself, and can scarcely be judged of by ordinary parallels.

I confess that to my eye it has always appeared as a glorious conception, though one not often to be repeated. Had its flanking towers been completed in the same style, the two great towers which backed it up completed with their spires, and the odd little chapel which has been thrust into its central arch been omitted, I know few fronts to which it would yield in grandeur, and none in originality.

Peterborough once possessed a noble work in the latter part of the century, in its Lady Chapel, but only a few fragments remain. Its mutilated cloister, the gateway to the Bishop's Palace, and the

Digitized by Google

ruins of the Infirmary, are beautiful works of this period. I know few cathedrals which externally I more enjoy than Peterborough. In old coaching days I used often to pass through between four and five in the morning, and if daylight permitted, I made it a point of conscience to run round the cathedral while the mail bags were in course of arrangement, and never will the impression it produced on my mind be effaced. I know no more beautiful group than its western transept presents as you return upon it from the north-east.

We come here into a country replete with village churches, many of which are in our style. Warmington, for instance, between here and Oundle, is an almost perfect thirteenth-century church, and I only mention it as one specimen, for time would fail me to enter upon even an enumeration. Off to the north-east too, there is West Walton, with its splendid and unique detached tower—an almost unequalled example; and nearer at hand are the mournful and tottering relics of the sister Abbey of Crowland, the details of whose western front are hardly to be surpassed, and are the more interesting as having been evidently the work of the architect to the eastern part of Lincoln Cathedral. Even the stone is from Lincoln, though it is a material not used in the district.

As you go from Peterborough to Lincoln, whichever road you take, there are endless series of village churches, as well as others of greater pretensions. Stamford is rich in work of this age, but I will only allude to the churches of St. Mary and All Saints. Close by is the beautiful Early English tower of Ketton. Grantham possesses the most stately steeple (next only to Salisbury) in the kingdom; and on another road I may mention Frampton, as having the most perfect of all simple early towers and spires that I know. But let us hasten on to the crowning glory of the district, whose lordly towers preside in serene majesty over the whole surrounding country.

No English cathedral is, externally, so imposing as that of Lincoln, nor do I recollect any abroad which as a whole surpasses it; and nearly the whole of its sublime architecture belongs virtually to this century, though in actual date it begins a few years earlier, and ends a few years later.

It is the custom to speak of Salisbury as the great typical example of the Early English style, and its unity and completeness may warrant the claim; but, both for the grandeur of the whole and the artistic beauty of every part, and also as a complete exponent of English architecture throughout the whole duration of its greatest period, Lincoln far surpasses it. Its leading features form a perfect illustration, and that on the grandest scale, of the entire history of our architecture from the last years of the twelfth to the earlier part of the fourteenth century.

As I have so often mentioned, the Pointed style commences here with the choir, the smaller transept, and the chapter-house, all of which seem to have been erected before the year 1200, by Bishop Hugh. It is commonly stated that his architect was a Frenchman from Blois; and M. Lassus broadly states that he reproduced at Lincoln, in 1188, the design of a church commenced at Blois in 1138. I am not able to speak as to the authorities on which these statements are founded, but I must say that the internal evidence afforded by the building itself gives it, so far as I can judge, little or no support. In the first place an eastern transept, in addition to that at the main crossing, is much more frequent in England than in France: whether the cathedral of Blois (now destroyed) possessed this I do not know. In the second place the polygonal chapter-house is an equally English feature. In the third place one of the most remarkable characteristics of this work is the nearly universal use of the round abacus,—that distinctively English detail, and that at a period somewhat earlier than that of its general predominance. The general distribution of the parts seems to me rather English than French, and though the work displays some idiosyncrasies, I do not see in them anything to indicate a French origin, unless it be in the capitals of the main pillars; indeed, it is a work in which distinctively English characteristics appear in a somewhat advanced state of development. As to its being a reproduction of a work commenced at Blois in 1138, the assertion carries with it its own refutation; for, in an age of restless progress, is it likely that they would take the trouble to bring over a foreign architect of so retrograde a taste as to ignore the artistic progress made in his own country during half a century? In fact, the wonder of the work is being so much in advance of its age, and that advance is not in a French but an English direction. The Church of St. Nicholas, at Blois, is in the Early Pointed style of the latter half of the twelfth century, but bears not the least resemblance to this,—it is of the same character which is usual in French transitional works, and its carving is strictly Byzantine, not a trace of which I have observed at Lincoln. If then a French architect was engaged here, he must not only have made over the details of his work wholly to Englishmen, but have studiously followed English forms in the general features.

The rebuilding of the cathedral seems to have been followed on systematically westward by the two successors of Bishop Hugh, till the completion of the nave by Bishop Grostete, about 1240.

The nave is by far the finest portion of the work as then completed, and is probably in the whole the grandest example of the Early Pointed style in this country,—it exhibits our Early English style in its highest state of development: massive without heaviness, rich in detail without exuberance, its parts symmetrically proportioned and carefully studied throughout, the foliated carving bold and effective,—there seems no deficiency in any way to deteriorate from its merits.

The west end is unique, being a vast and almost unperforated wall covered over with range upon range of decorative arcading, flanked by two vast stair turrets, and backed by two noble towers, the completion of which was however delayed till a much later period. It always strikes me as a very impressive front, but I find that it does not strike all eyes so favourably. I would call attention to the beautiful chapels to the right and left on entering from the west, with their light and elegant columns contrasting most agreeably with the massive piers of the nave; also to the noble rose window in the north transept, perhaps the finest in England.

The most gorgeous part however of the cathedral is its eastern portion. This was added between the years 1256 and 1282, and is consequently a little later than Henry III.'s work at Westminster. It agrees with it in style, but carries out the principle of window tracery on a far grander scale. It is in fact the most splendid work of that period which we possess, and, did it not lack internal height, I do not think it could be exceeded in beauty by any existing church. The sculpture with which it was once profusely enriched was of a very high order, the foliated carving perfectly exquisite; the mouldings and other details of the most perfect character. The east window is probably the finest in the kingdom, as is the east front in general, after allowing a certain abatement for the error of having false gables to the aisles. I have already mentioned the exquisite portals, the sculpture in which is superb, and our gifted Professor has published his views as to that which adorns the triforium. The student of mediæval art ought to make a long sojourn at Lincoln, and study its treasury of art at his leasure; not forgetting by-the-bye the beautiful remains of the chapel to the Bishop's Palace hard by the cathedral.

In passing northward from Lincoln a profitable digression may be made to Southwell, whose noble choir seems to be an emanation from Lincoln, and its far-famed chapter-house from York;—and to Newstead, whose beautiful west front and lovely carving agrees in style with the eastern portion of Lincoln.

Yorkshire is especially the land of minsters and abbey churches: to attempt here a description of them would be vain. A Yorkshire tour is one of the richest treats the student can look forward to, and one to which he ought to be liberal in his allowance of time. At York itself the transept is among the finest examples of the earlier part of the style; and the ruins of St. Mary's Abbey of its later portion. I know few works so enchanting as the latter. It agrees in date with the east part of Lincoln, and is not unlike it in detail. It is a mere wreck, but worthy of the closest study; and the shattered fragments which lie on every side offer melancholy facilities to the student. The chapter-house of the cathedral is a little later, and has been well called a *Domus domorum*, though I would not willingly admit its superiority to those of Westminster or Salisbury. The neighbouring village church of Skelton—said to have been built by the same hands as the transept of the cathedral—and the ruined chapel of St. Leonard's Hospital, in the gardens round the abbey, show how unerringly the same style fitted itself to works of the most stupendous and on the humblest scale.

This great county is filled with the noble productions of the thirteenth century. The minsters of Beverley and Ripon owe much of their beauty to it; and scarcely one of the abbey churches whose lovely but mournful ruins add a charm so melancholy to the secluded valleys of Yorkshire, fails to show the work of the great period. I cannot attempt even a cursory description. Go,

Digitized by Google

I pray you, and study for yourselves. Go to Fountains Abbey, and study well its choir and eastern chapels, with their massive pillars—the tallest perhaps in England—and the remains of its wonderful abbatial hall, exposed to view by the recent excavations; and its many other wonders. But do not be satisfied with a passing visit,—take up your quarters at Ripon, and follow up your studies from day to day: a week is but a short allowance for so rich a school of art. Then go to Rievaulx and Whitby,—twin works, it would seem, of the same accomplished architect; I cannot award the palm to either,—they are truly a *par nobile fratrum*, and it is fair to prefer whichever of them we have seen the last. Their great point of difference is that the choir of one has been vaulted, and that of the other has shown its timber roof; but in glorious architecture they are equal, and almost unequalled. As you go from York to Whitby you pass a small fragment of the Abbey of Kirkham: stop and look at it, small as it is, it is one of the best designed pieces of work I ever saw. If from Whitby you cross the Moors to Guisborough, you will see what was probably the work of the very end of the century,—the stupendous east end of that abbey, with its east window exceeding even that of Lincoln in height.

If you go on to Durham, the Chapel of the Nine Altars will rivet your attention; and further yet, at Hexham, at Dryburgh, and far on through Scotland, to the Chapel at Holyrood, and the glorious remains of Elgin Cathedral, and that noble temple yet preserved unruined at Glasgow, you will find a long series of the footsteps of the art of this wonderful age. In returning, pray look in at Furness Abbey, where you will find an absolute gem of our style in the ruined chapter-house. I intended to have had prepared an illustration of this exquisite little work, but time has failed. It has been of the same construction with the Temple Church, and of exquisite beauty. But a mere catalogue is both useless and wearisome. I have passed over the whole series of southern examples,—as Hythe, Shoreham, Winchester, Boxgrove, Wells (the glory of our style), Llandaff (one of its most original productions), Worcester, Lichfield, Hereford, and a hundred more examples, all of which supply proofs of the wonderful perfection of the architecture of this century.

I ought also to have called special attention to the circumstance, that while in France nearly every great church is vaulted, such is not the case in English works,—they seem to have acted with perfect freedom in this respect; and their churches, even the largest of them, have frequently had open timber roofs, and suffer little by the variety.

One thing cannot fail to strike every one who closely studies our old architecture. In early Norman buildings we often find rude and clumsy workmanship; in works from the middle of the fourteenth century, on to the extinction of Gothic architecture, we frequently meet with the same,—the work of rude untutored hands, evidently unable to do justice to their style. But from about 1175 to the end of the thirteenth century, and a little later, we scarcely ever meet with this inequality. The art seemed to be all-pervading. Certain buildings may have been plain to a degree, and rustic in their object and material, yet you rarely find anything you can call rude in workmanship, or unskilful in treatment. It was a great period, and its greatness seemed to pervade even the most secluded districts, and the workmen everywhere to have felt a pride in keeping up the period of their art in which their lot had been cast. Nor need we wonder at this, for everywhere were buildings going on; scarcely a village church escaped the notice of the builders of this wonderful age. The whole country was engaged in the one work of building, and that with an ardent feeling to render their work worthy of the style they had generated.

And let us not imagine that the architecture of the age developed itself only in building cathedrals, abbeys, or churches of any kind; all other buildings evince the same spirit: a barn of the thirteenth century shows the nobleness of the pervading style as clearly as even the cathedral itself, and what remains of their domestic architecture tells the same tale. Everything was done well, in good taste, and in accordance with reasonable and practicable requirements and the means at command. Nor was it to architecture alone that the arts of the period were devoted: we find the same art expended on stained glass, on metalwork of all sorts, on enamels of the most magnificent character, on the illumination of manuscripts, the painted decoration of the buildings, on jewellery, on ivory-carving, on embroidery, on woven fabrics, tapestry, seal-engraving,—in fact on every branch of decoration; every one of which arts are carried out with a degree of skill and instinctive taste truly amazing. All these branches should however be treated of separately.

In my enumeration of buildings I have limited myself to our own country; but we all know that in France the same great facts are if possible yet more wonderfully proved. The architecture of the thirteenth century in France is rendered illustrious by an endless category of buildings, the most glorious perhaps which the world has produced.

Germany, though her style is broken harshly by the cause I have before alluded to, nevertheless furnishes, whether in the native variety of the former, or in the adopted one of the latter half of the century, a series of buildings of which any country might well be proud.

In Italy the style was certainly imported from the North, but was it an unnatural transplantation? I should say, by no means so. Had not Italy her own Romanesque, which she had in some degree imported to northern countries; and have I not shown that Pointed architecture was a natural and logical development from Romanesque? Why, then, should it be accounted foreign to the land from which Romanesque itself had sprung?—and if the growth of Pointed architecture was aided by ideas culled from Byzantium and the East, why should those ideas be less suited to Italy than to France or England, whose communications with the East were far less direct? Did not she take part in the same crusades,—nay, did not the Byzantine element in French art actually come there through the medium of Italy? Let us not then deny to her a fair participation in the architecture of the age. We had it before her it is true, but let us not on that account say that it is none of hers.

The great fault in the mediæval architecture of Italy lies in its details, such as its mouldings, &c., which evince too much of their antique original; its great value lies in its use of materials of varied colour, of inlaying, mosaic work, and other decorative arts, inherited also from the past. These arts ally themselves well to our style, though the classic mouldings do not so, and in our judgment of Italian work we should never lose sight of this; we may otherwise be led either to reject real merit from the offence which incongruous detail offers to our taste, or we may be led to accept what is bad and spurious, because gilded over and its demerits concealed by beautiful art, which would appear to greater advantage if united with purer architecture.

Another point however which gives great value to the mediæval art of Italy, arises from the somewhat accidental circumstance that her internal position was such as to require town buildings very much of the kind which we want now. The consequence is that Italy was, even in these earlier days, the land of street palaces, and that we find yet remaining there numberless buildings of a class which we find but rarely in other countries, and those treated in a manner very parallel with what we often require at the present day. Not, let it be born in mind, that they are treated in a manner essentially different from the coeval works in more northern countries, but rather that there were more of them,—that these were on a larger scale, and that more of them have remained to our own day.

It is a mistake to suppose that the secular architecture of Italian cities essentially differed from that of the same period elsewhere. If you will carefully look through any book showing specimens of the domestic architecture of France in the thirteenth century, you will find that it closely resembles that of Italy, except in having purer details. The same kind of window for instance which from habit people had got into the way of calling Italian or Venetian, prevailed in France and Germany, and is often found in England.

I could give you a series of Italian, French, German, and English windows of early date where you could scarcely distinguish the one from the other; indeed, you would seldom be able to detect an Italian window at all if divested of the accidental clothing of its non-essential details. This establishes the unity of the style; yet the fact remains that works of the kind are more abundant, larger, and more developed in Italy, and that they may consequently be studied there to great advantage as an aid and expletive to what we learn elsewhere.

This brings me to the concluding subject of my lecture,—the question of what lessons we should learn from what has passed in array before us, and what effect it ought to have on our own artistic practice.

It would be hopeless to enter upon the general question of the revival of styles. I will suppose that question to have been dis-

Digitized by Google

posed of for us, and limit myself to considering what is the most reasonable course to follow in conducting such a revival, or rather in carrying on the development of a style upon a revived basis, such as that of the architecture we have been considering.

Now such a revival, to begin with, is hardly to be viewed as a deliberate act; a man would scarcely be bold enough to make up his mind, *à priori*, to revive a style of architecture: circumstances must have gradually led to such a course, and it must have been set about gradually, and almost unconsciously, to give it a chance of success. We may, in looking back upon what has taken place, construct a very good theory for it all, but no such theory really led to it,—it came about very much of itself. We may by thought and by studying our position do a little in finding an existing movement,—but the movement itself must have arisen from some more hidden and deep-seated cause, or it would have died away long ago. What then does this deep-seated feeling demand, and with what will it be satisfied?

It craves spontaneously after a great style of art, which it sees to have been once the birthright of our race. It demands that we should,—I will not say simply *revive* that style of art, but that we should *revivify* it; not that it should be reproduced as a splendid pageant, to be re-enacted for the sake of gratifying our romantic or antiquarian predilections, but that we should rekindle its actual life; and having done so, should not only think, and design, and invent in that style as the living medium for the expression of our artistic aspirations, but that we should cause it to take root, to spring forth, to germinate and ramify,—to shape itself to all the demands of our age, and to adapt itself to its materials, its discoveries, its inventions, and its science; in short, to become in every sense a living, a vigorous, a growing art.

Now, to further such an object, what is the best manner in which we can make use of the lessons to be learned from the past creations of that style? One of the lessons I think we should learn is to work in the same free and liberal spirit in which our forefathers worked; not to do what they did, but as they did. If we, on the one hand, shut ourselves up in our own country, and, reproducing the style we find to have prevailed here, sulkily reject the lessons to be learned from neighbouring lands, we may produce a servile reproduction of what was done by our predecessors, but shall be acting anything but as they acted. If, on the other hand, we travel widely, and, giving free license to our individual preferences or momentary fancies, we import now this style and now that; here building in a French, there in an Italian variety of our style,—we shall in each case be doing what was done in one or another province of mediæval art, but shall be equally free from doing as the old artists did: the one course involves servility, the other adds to it frivolity.

The great principle on which the mediæval architects of each country instinctively acted was, while adhering in the main each to the dialect of the great art which happened to be current amongst them, to improve it by the free importation of ideas and adoption of hints from whencesoever they might be derived, but especially from the dialects of the same artistic language. Thus for instance, the Pointed architecture of the Royal Domain of France is as a whole a logical sequence of the Romanesque of the same district,—yet no scruple was felt at importing into it the Byzantine capitals and foliage which had come to them through the medium of Venice, and to this foreign importation they owed some of the greatest beauties of their architecture; nay, if the oriental origin of the Pointed arch be true, they went further, and engrafted upon their traditional art a feature learned from the infidels they were combatting. Again, the English Pointed may be traced step by step from the preceding style, yet they had no hesitation about introducing into it details developed by the French. The Germans carried the principle too far: giving up their own traditional variety of Pointed architecture, they adopted the French developments ready-made,—yet, having done so, they worked them up in a manner quite their own: while in Italy, the new style having been brought in upon the pre-existing Romanesque, they soon elaborated it into a dialect as distinctively characteristic as those of other European countries. Besides this, no nation had any scruples about employing artists belonging to another; so that the advancement made by each became in a degree the common property of all, and even the woven fabrics and other manufactures imported from the far East were allowed to offer suggestions to the European decorator.

To follow out the same principle we ought, while especially making ourselves masters of the architecture of our own country, and using it as the groundwork of our revival, nevertheless to view the style as a whole, and, while not forsaking our own provincial dialect, to make ourselves masters of the entire language. We should not wish our revived art to be indistinguishable from that of our forefathers. It should certainly reflect some of the characteristics of our own age, one of which is our enormously increased habits of locomotion; and as we visit all the districts where our style prevailed, nothing can be more natural than that our revived art should show the effects of our more extended sphere. Knowing, as we do, that France was the central district—the very heart—of mediæval art, should we not be insane not to study well her glorious monuments, and having studied them to enrich our own style by the many lessons we may learn from them? It has been suggested that we should do this, especially as regards those of the provinces of France which were once subject to the English kings. I would not reject the historical interest which this connexion naturally gives rise to, and I doubt not that those provinces are rich in instruction; but I would not on that account neglect the fact that it is the *Royal Domain* of France—the district of which Paris is the centre—which was the special focus of our art. Look again at the ancient cities of Germany,—perfect storehouses of old architecture; let us never be so suicidal as to reject the lessons they offer! "So far," some may however say, "is all very well; but, for goodness' sake, do not cross the Alps! Ruskin has driven you all mad about Venetian, Veronese, and Florentine architecture; be more of men than to be led astray by popular writing. You cannot but see that Italian Gothic is very corrupt, though somehow or another very captivating. Listen not then to the syren's song; reject the enticing bait, nor pollute the pure stream of Northern art with the corrupted waters of the South."

I admit that there is some ground for such a caution,—there is a mysterious fascination about Italy, which has led astray many who have visited it before they had grounded themselves firmly upon a northern foundation; but is this a reason for rejecting all the lessons she offers? Was not Italy the land of ancient art, of painting, of sculpture, of mosaic work? Is she not the land of marbles and richly coloured material, and the land of ancient municipal institutions and of the edifices to which they gave birth? Her Romanesque architecture was the parent stock of our own; and if our Gothic was in its turn the stem from which her's sprung, surely its transplantation into so prolific a soil offers the greatest possible *primâ facie* grounds for expecting a rich variety to spring forth from it,—and such has been the result. It is for us to use it with judgment: rejecting what is in its own nature defective; not bringing into the north any features which are the result of a southern climate, but judiciously culling such suggestions as will with advantage unite themselves to our English nucleus; and especially let us take advantage of the lessons it affords us in the use of rich materials of mosaic and fresco-painting, and in any suggestions it offers for the perfecting of our secular architecture. Only let us do so with judgment, never forgetting that it is in England that we are working, and that if we borrow ideas from France, from Germany, or from more southern lands, those ideas must be expressed *in English*—a language, in art as in literature, of whose antecedents we find abundant cause to be proud.

Let us also remember that, though we must be ever learning, it is not by this alone that an art is to be generated; that we must act for ourselves, as well as learn from others: and that it is to our own vigorous and manly exertions we must trust to make the art we are reviving shape itself to the necessities and the spirit of the age we live in.

A correspondent of the *Journal of the Franklin Institute* writes,—"In almost every instance of destruction of steamers by fire, access to the engine has been cut off; and while the flames are driven aft by the speed of the vessel, they have no means of obtaining water. Could not a syphon-like pipe be introduced when the vessel is being built, extending the whole length of the same, through which the water would flow freely, so as to give motion, when necessary, to a hydraulic ram when required? The highest part of the pipe should be well aft, and it should not be higher above the water line than the point to which the minimum speed of the vessel would cause the water to rise; cocks could then be attached at various places, so as to draw water if necessary."

Digitized by Google

NEW GRAND ENTRANCE TO ST. JAMES'S PARK.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—"If you move I stickee; if you don't move I stickee," is said to have been the salutation addressed by a negro private of one of our West India regiments to a gentleman to whose front he presented his bayonet, the gentleman being found one night within some interdicted boundary, and unable to give the requisite pass-word. Now this salutation appears to be pretty much of the same character as the treatment the Metropolitan Board of Works has received. At first the public press voted them altogether *too slow*, because they could not immediately and by intuition settle what was the best plan of dealing with the great and complicated question of the main drainage of this metropolis, and the very ticklish question of how to get the metropolitan rate-payers to pay the piper. Having, notwithstanding the confusion and clamour created by the advocates of the various rival systems, arrived at some kind of conclusion in this matter, and being about to carry out a plan which had received the sanction and concurrence of the great engineering authorities of the day, it was then found the Board was going *too fast*, and it was deemed right to watch their proceedings very closely, to see whether some extravagances were not being perpetrated which ought to be publicly and energetically denounced; and at last it was discovered that the Board intended to remove its offices from the neighbourhood of the Seven Dials (where they now are)—a nice secluded position, very proper for the jog-trot Commissioners of Sewers of the olden day, but not quite the sort of situation for the offices of a public body charged with the management of this great metropolis—to the centrality and prominence of Charing-cross; it being proposed at the same time to make a grand entrance into St. James's-park from Trafalgar-square. Now the throwing open of the mall of St. James's-park to the Strand and Trafalgar-square, one would think, ought, *if properly done*, to be one of the most magnificent of London improvements, and it would appear wise not to oppose the project of removing the offices of the Board to Berkeley-house, St. James's-park, provided the opening is a sufficient and proper one; that is, that it extend from Cockspur-street to the entrance to Spring-gardens, opposite King Charles' statue, which would afford a grand *coup d'œil* from Trafalgar-square or from West Strand, somewhat resembling the Champs Elysèe of Paris. It need not be feared that the "quiet seclusion and sylvan character" of St. James's-park would be affected by this alteration, for such opening would not affect the inclosed part of the park, except beneficially by letting in more air; and that inclosure is the only part of the park that can be fairly deemed "quiet" or "secluded." It does not follow that because we should then have a broad and noble entrance for passengers and carriages, that therefore omnibusses and Pickford's waggons must race up and down as they please; the roadway along Birdcage-walk is not subject to heavy noisy traffic, and the proposed roadway might be similarly privileged.

This scheme of the Metropolitan Board, if looked at in a broad and liberal manner, deserves not public opprobrium but public support, and it certainly is anything but charitable to say that the motive which induced the Board to select Berkeley-house for head-quarters, was flunkeyism, or the desire to possess a fashionable *locale!* Without a personal knowledge of the members of the Board one cannot of course say whether this imputation is or is not founded on truth, but it is only fair to take the least offensive aspect of the question, which is,—that the Board, being a new municipal institution, of such character that, if it is to be anything at all, must be one of the first importance to this great capital, that therefore it is not meet and proper that it should be hid away in a corner, and truly Greek-street, near Seven Dials, is not a suitable public situation, whilst Charing-cross is an eminently central and accessible one; and the removal would afford the opportunity of effecting a splendid improvement. Doubtless the Metropolitan Board is not all perfection, but it is not a congregation of incapables, and although all the members may not belong to the upper ten thousand, yet they are gentlemen of good social position, and in Mr. Tite we have an eminent architect of high character and position. For the sake of the great improvement which may be effected in connection with this change of offices, it is to be hoped the scheme will be persevered in, and properly carried out; and if it be, it need not create any very heavy burthen on the rate-payers, as the value of the building sites on each side of the entrance ought considerably to lessen the expense.

MEGALOPOLIS.

CONTINENTAL ART GOSSIP.

EXCAVATIONS of great interest have been making beneath the well-known basilica of San Clemente, at Rome. In working towards the atrium, two Christian sepulchres have been discovered, which must have stood in the aisle close to the entrance of the primitive basilica. One is supposed to contain the remains of St. Cyril, and has been carefully sealed up. The other is highly enriched with sculptured foliage, and a head in basso-relievo unfinished.

A new museum of Christian antiquities of the utmost interest has been formed by Pius IX. in the Lateran palace. The walls of the principal *sala* are adorned with original frescoes removed from the walls of the Catacombs, or copies from others which it was found difficult to detach. About the floor are disposed various Christian sarcophagi, some of them exceedingly rude and even grotesque, others of great beauty,—but all deeply interesting for their typical and symbolic representations. The corridors of the Lateran are to be employed as a lapidarian museum, to relieve the over-crowded Vatican of the *embarras* of these precious records graven upon stone and marble.

The very interesting basilica of Sta. Agnese fuori le Mure has undergone a thorough repair, and workmen are now engaged upon the adjoining circular church of Sta. Costanga.

Flatz, a German artist of the ascetic school, but who combines with intense religious sentiment in his works great grace and purity of drawing, has several commissions for England on hand, —notably those works for the domestic chapel of Mr. Blundell, of Ince, the principal subject being "Christ leaving the temple after his dispute with the doctors."

Gibson, "*il famoso*," as the Italians call him, is hard at work. He has completed a copy of his famous coloured Venus for Lord Sligo. He is now engaged upon an exquisite statue of Pandora, for Lady M. Alford, and this is to be painted and gilt; and he has a Hebe on hand, also to be coloured. Gibson's refined taste in his coloured sculpture is more likely to remove a general prejudice against this revival than pages of angry controversy.

The Prince of Syracuse has paid a compliment to an English artist, by reproducing in the most exact fac-simile as to form, illustrations, paper, &c., a translation into Italian of the little but most curious and interesting *brochure*, 'On the Proportions of the Human Frame,' by J. Bonomi, F.R.S.L., the principles of which were explained by that gentleman in a paper read by him before the Royal Institute of British Architects, and given to our readers in our number for February.

Tenerani, the eminent Roman sculptor, is working on a grand colossal group to form a monument to Pius VIII. It exhibits all the admirable qualities of the artist,—breadth, dignity, and repose.

We fear the result of the Lille competition will hardly have encouraged English architects to enter upon the competition which was invited some little time ago for designs for the restoration of the central tower of the noble old church at Bayeux As the building exists at present there is a rich octagonal Flamboyant lanteru, terminated by a miserable dome in the Italian style.

At Nantes three churches of unusual importance have been just brought to a conclusion. St. Nicholas is one of the most important ecclesiastical edifices of the day, consisting of nave with double aisles, transepts, apse, with procession-path and radiating chapels. The style is the pure French 13th century, most admirably carried out; the name of its lamented architect, Lassus, being a guarantee for its excellence. A presbytery full of character and common-sense architecture adjoins the church. St. Clement is another spacious edifice, also in the 13th century style, and of very considerable merit; it is from the designs of M. Liberge, of Nantes. Notre Dame de Bon-port is in the Renaissance style, with a dome at the crossing of its nave and transepts.

A remarkable church is about to be erected in Algeria, from the designs of M. Fromageau. It has a vestibule, square nave, and apsidal transepts, and chancel, with a dome at the crossing. The architect has exhibited considerable ingenuity in combining Byzantine and Moresque characteristics, but we are inclined to think has allowed his ingenuity to trench upon good taste in some regards. A large amount of decoration is to be obtained by a free use of enamelled earthenware; and the dome is to be covered with gilt copper banded with crowns of bronze and points of crystal.

Digitized by Google

LOCOMOTIVE ENGINE SHED AND TURNTABLES AT THE GATESHEAD STATION.*

(With an Engraving.)

In the arrangement of large engine sheds the important points requiring consideration are capacity and economy of construction, combined with facility of ingress and egress for the engines at all parts of the shed. In the shed forming the subject of the present paper, which is erected at the principal locomotive works of the North Eastern Railway, at Newcastle-on-Tyne, an unusual number of engines had to be accommodated in one place; so many that five separate buildings of the ordinary polygon arrangement would have been required, entailing a very heavy cost of construction.

From the convenience of the polygon arrangement for access to all the engines, the same general plan was adhered to as regards the engine pits and turntables, which are arranged as shown in the general plan, fig. 1 (see Plate), in the same manner as if five ordinary polygon sheds had been constructed close together, in two rows alternating with each other, so that the lines joining the large turntables AA, in the centre of each polygon form three equilateral triangles. By this arrangement of plan, a direct line of rails is obtained communicating from every turntable to each of the adjoining ones; and several distinct roads are obtained for entrance or exit at each of the turntables, one of them having five separate roads, while two of them have four, and the remaining two have three roads each. Then instead of having the expense of building that would have been involved by the construction of five separate polygon sheds, requiring a long range of wall and an expensive construction of roof on account of the large span and polygon form, the whole area has been inclosed by a plain rectangular wall FF, and covered in by five ordinary parallel roofs of moderate span, supported by four rows of columns running the entire length of the building, and falling into the intermediate spaces between the pits, without interfering with any of the lines of rails, as will be seen by the plan.

The result obtained is a covered area of 126,000 square feet, instead of 88,257 square feet, which would have been the area of the five polygons, or an increase of 43 per cent. in the area, with a reduction of 37 per cent. in the length of walling, which is 1476 feet in the rectangular building, instead of 2340 feet; the cost of construction being reduced in a considerably greater proportion, from the simpler and cheaper description of work in the rectangular building as compared with the polygons.

The additional space obtained in the rectangular building is found of great utility and convenience for carrying on the minor repairs done in an engine shed, such as changing wheels, &c., which is here accomplished without occupying any of the lines used by the running engines. For this purpose strong lifting frames are fixed over the spare lines in those parts of the shed, as shown at BB in fig. 1, fitted with gearing for lifting the engines. Fitters' benches are also erected in the open spaces of the shed, as shown at CC. At DD are fireplaces for warming the shed and lighting the engine fires.

Fig. 2 is a transverse section of the building, showing the five separate roofs, of which the three centre roofs are 65 feet span, and the side roofs 42 feet 6 inches, making the total width of the building 280 feet. The total length of the building as shown in the drawings is 450 feet; but only two thirds of this, or 300 feet, is at present built; the portion EE in the plan, fig. 1, including two of the turntables, not being yet constructed.

Fig. 3 shows an enlarged transverse section of one of the 65 feet roofs. The principals are fixed at 12 feet 6 inches apart, and the purlins are trussed with wrought-iron flitches, 4 inches by ¼ inch, with 4½ by 4 inches wood. The principal rafters are constructed of two bars of channelled iron 4½ inches deep by 1½ inch wide on the flanges, with a 2¼ inch space between them, into which the T iron struts are fixed. The cast-iron columns supporting the roof are fixed at 25 feet apart, and connected by cast-iron girders; and at F in the plan, fig. 1, one of the columns is omitted for the convenience of the oblique lines of rails, and a wrought-iron girder of 50 feet span is introduced.

A plan of one of the engine turntables is shown in fig. 4, and a longitudinal section in fig. 5, with a transverse section at the centre in fig. 6, and a section at the end in fig. 7. The table is 42 feet diameter, and consists of two main wrought-iron girders GG, 3 feet deep at the centre, and 2 feet deep at the ends. These girders are secured together by a cast-iron cross H, which fits upon the fixed centre pin I, by a cylindrical socket, extending the whole depth and turning freely upon the pin. The centre pin is of wrought-iron, 9 inches diameter, and is fixed into a socket 2 feet deep in the pedestal K, bolted down to the foundations; the pedestal is shrunk upon the pin, which is then secured by a key. The bearing for the table is taken at the top of the fixed centre pin I, by a short steel pin L, 6 inches diameter, which revolves in a socket 5 inches deep in the top of the fixed centre pin I. The bottom of the pin L, is rounded at the edge, and turns upon a steel plate 1½ inch thick at the bottom of the socket. The pin has a flange at the top carrying a cast-iron cap, from which the whole table is suspended by six bolts taking hold of the cast-iron cross H, the bolts giving the means of adjusting the level of the table.

The outer ends of the girders are fitted with sliding wrought-iron wedges, which are moved by the handles M, and when pushed out rest solid upon cast-iron chairs, fixed upon the outer foundation curb at the end of each line of rails, and support the ends of the girders whenever an engine is being moved on to or off the table. A pair of safety rollers N, is added at each end, running upon a circular rail O, but not in actual contact with the rail in the ordinary working of the table, being applied only as a precaution to prevent strain, from the weight not being balanced on the table, or in case of accident to the centre pin.

An engine and tender is readily turned upon the table by two men pushing at the end, without requiring gearing; the weight is so nearly balanced upon the centre pin that the rollers at the ends do not take any appreciable weight in regular working; and the due placing of the engine on the table for this plan is sufficiently ensured in practice by the circumstance that any neglect in this respect would increase the resistance to be overcome in turning the table.

An important advantage in this construction of turntable is the great facility for examining and keeping in order the only part that is subject to wear, namely the steel centre pin; this is readily done by fixing the sliding wedges at the ends of the girders, when the table becomes a rigid portion of the line of rails, and the steel centre pin is taken out by simply unscrewing the six nuts, and the socket is readily examined, being close to the top of the table. These turntables have now been two years in constant use, and have given entire satisfaction, no attention having been required beyond ordinary oiling, and only one of the steel centre pins having required to be taken out for examination during the whole time.

* Paper read at the Institution of Mechanical Engineers.

CHESTER CATHEDRAL.

It is proposed to raise a memorial in Chester Cathedral to John Pearson, once bishop of that diocese—well known as an author—and who died in 1686, being buried in the cathedral, within the rails of the altar, but without any memorial even to record his name. The kind of memorial is to be determined hereafter, according to the wishes of the subscribers; it will probably be either a monument bearing the effigy of the Bishop, or a window of painted glass, erected at the east end of the chapter-house; or a restoration of the great east window of the lady-chapel, near which his body lies. This latter subject has been for some time in contemplation, independently of the purpose just adverted to, inasmuch as the present "perpendicular" design is not only unworthy of, but quite inharmonious with, the surrounding architecture, which now, after a long and expensive process, may be considered as restored as nearly as can be ascertained to its original design. The *coup d'œil* which the lady-chapel now presents is one of surpassing beauty (with the above exception), the details throughout are of the best period of the Early English era, and the whole is delicately, yet richly relieved by polychrome and gilding. This latter department has been most efficiently undertaken by Mr. Octavius Hudson, the results of whose skill at Salisbury and Ely are well known. It may be well to add that Mr. Hudson's system of colouring has not been founded on conjecture, but his extensive acquaintance with the subject, based on the examination of our principal mediæval edifices, renders him a peculiar authority in such matters, and for the decorations at Chester it appears that he has in most cases been able to detect remains of ancient colouring, which, it is needless to say, have been reproduced with scrupulous care.

Digitized by Google

LOCOMOTIVE ENGINE SHED AND TURNTABLES.

Fig. 3.

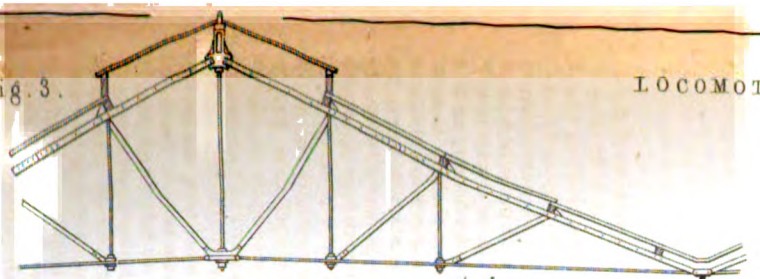


Fig. 1.

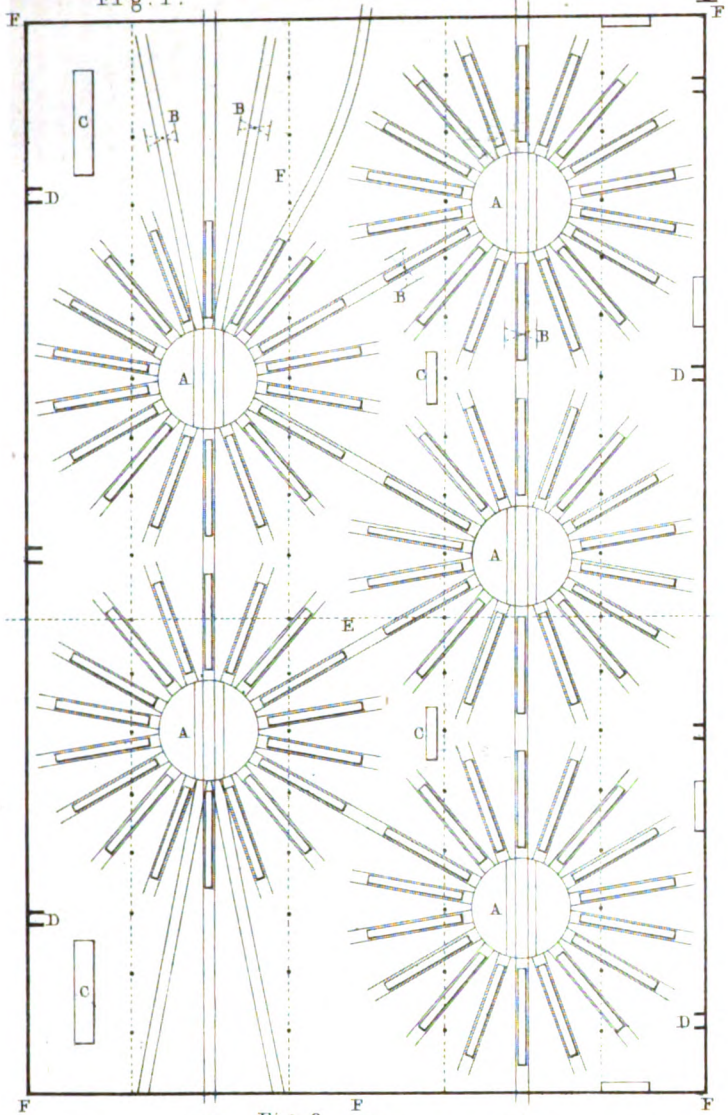


Fig. 2.

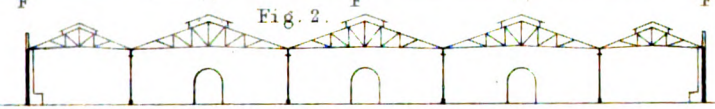


Fig. 4.

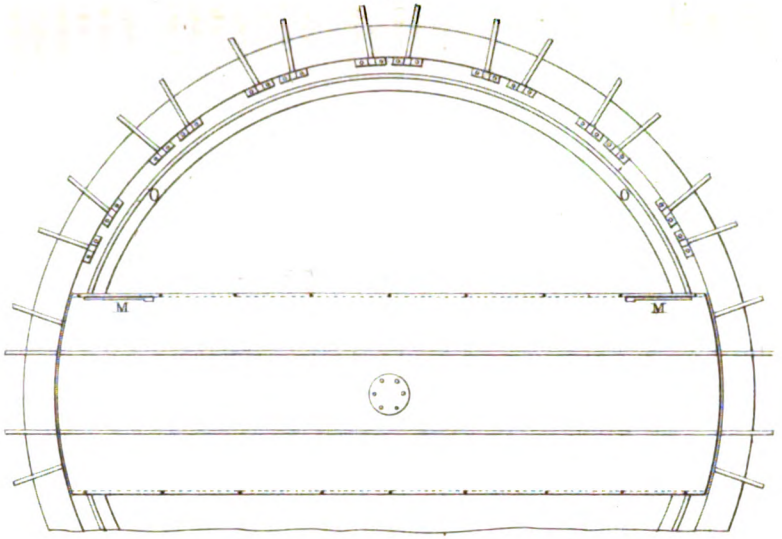


Fig. 5.

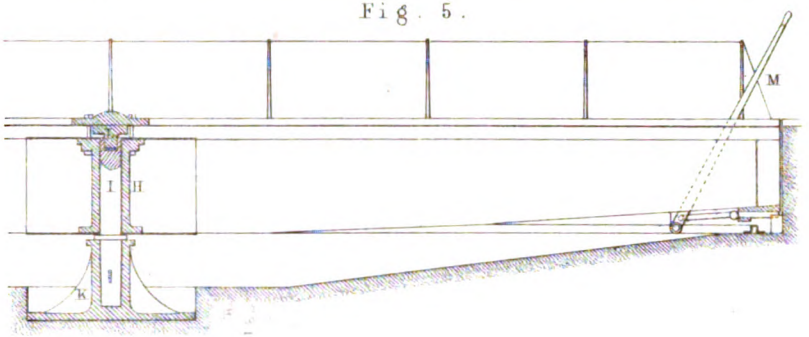


Fig. 6.

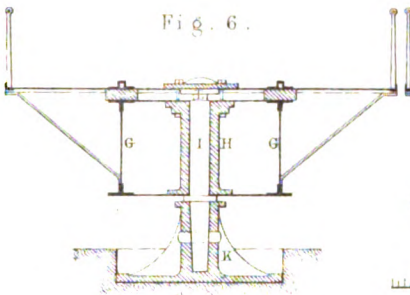
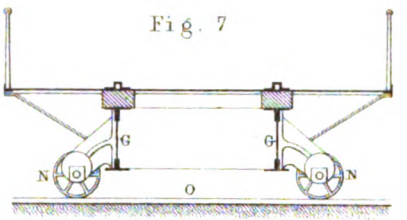
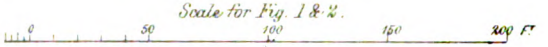


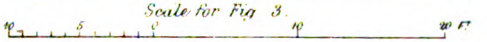
Fig. 7



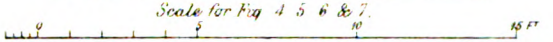
Scale for Fig. 1 & 2.



Scale for Fig. 3.



Scale for Fig. 4. 5. 6. & 7.



J.R. Jobbins

Digitized by Google

Digitized by Google

INSTITUTION OF CIVIL ENGINEERS.

JOSEPH LOCKE, Esq. M.P., President, in the Chair.

February 15 and 22.—The Discussion upon Mr. JAMESON'S paper, "*On the Performance of the Screw steam-ship Sahel, fitted with Du Trembley's Combined Vapour Engine; and of the sister-ship Oasis, with Steam Engines worked Expansively, and provided with partial Surface Condensation,*" occupied both evenings.

In commencing the discussion it was observed, that experiments made with great care and continued over some time induced the opinion that surface condensation would ultimately supersede condensation by injection. It was found that a condensing tube 4 feet long and ½-inch in diameter would be sufficient for a non-expansive engine of $\frac{1}{10}$ H.P. Such a tube placed concentrically within one of slightly greater diameter, so as to allow only a thin stratum of condensing water to pass between the two, would condense 3 lb. of water per hour; the pressure in the condenser being only 0·96 of an inch of mercury, the temperature of the condensed water 24° centigrade, and the temperature of the condensing water before and after doing its work 7° and 18° centigrade respectively. The same tube would condense 30 lb. of water per hour, the pressure in the condenser being 23·2, the temperature of the condensed water 85° cent., and the temperature of the condensing water before and after doing its work 8° and 36° cent. respectively. An approximate formula for determining the vacuum in any particular case applied to the same condensing tube might be thus expressed:—the deficiency of the vacuum in the condenser, compared with that due to the temperature of the condensed water, was directly proportional to the quantity of water condensed in a given time, and inversely to the difference between the temperature of the vacuum and that of the condensing water.

A further account was then given of the voyage made by Mr. Rennie in the ship Du Trembley, in the year 1853, from Marseilles to Stora, in Algeria, and back. From this it appeared that there was a saving of fuel of from 50 to 60 per cent., and consequently that an increased amount of space was available for cargo. This advantage was partly counterbalanced by the cost of the ether, and the inconvenience and possible danger of its use, particularly in hot weather, when the vapour was at times diffused over the vessel, and became very inflammable. But these defects might yet be remedied.

It was remarked that the difference in the consumption of fuel in the combined engine and in an ordinary expansive engine being respectively 3·1 and 7·4 lbs. per I.H.P. per hour, seemed to indicate the superiority of the former system. But before accepting this conclusion it was desirable to examine the conditions of the experiment. In the first place, it was evident that there was a bad vacuum in the ether cylinder, which might be attributed partly to the difficulty of condensing that liquid, and partly to the exhaust ports being insufficient in area; for ether steam being five times heavier than water steam, the ports for its discharge should be twice the usual area. On the other hand, it was doubted whether in the expansive engine the cylinders had been properly protected; and it was stated that a loss of 50 per cent. had been known to occur from condensation in an unprotected cylinder when working expansively. It seemed therefore essential to inquire into the relative merits in a theoretical point of view, of the combined ether engine and a well arranged expansive steam engine. According to the dynamic theory of heat, heat and power were identical. The particles of a heated body were in a more agitated condition than in a cooler body, the motion of the particles being greatest in elastic fluids, and their pressure upon the sides of the vessel such, that if one side yielded (as was the case with a working piston), the reaction would be less than the impact. Hence the motion of the particles would be diminished in proportion as the piston was urged forward, and the result would be reduction of temperature. Expansion might be carried to a point where the elastic force was entirely exhausted. Commencing with steam of the density of water, and expanding it until a perfect vacuum was obtained, would form in point of principle a perfect engine. But the practical difficulty of carrying expansion to its utmost limits, was the great strength and size of cylinder required for the purpose. All the different air and other engines designed to supersede steam had aimed at one point, that of carrying the expansive action to a further degree without its being necessary to resort to such large and strong cylinders. In the combined engine the analogy was evident. The expansive action was stopped at a certain point, and the steam was made to impart its heat to another liquid, which evaporated at a lower temperature, and the vapour of which occupied less room than steam at a given temperature; so that a smaller cylinder could be employed. It was a matter for calculation whether this advantage was sufficient to balance the disadvantages of an imperfect vacuum in both the steam and the ether cylinders,—of the complications, and of other drawbacks which had been mentioned in the paper. It was believed, that by properly protecting the ordinary steam cylinders against the loss sustained from condensation, results would be obtained equal to those claimed for the ether engine.

It was remarked that a theoretical comparison of the relative merits of the ether or combined engine, and of an ordinary steam engine, was in favour of the former, as there was undoubtedly an addition of power. With reference to the possibility of improving the ordinary steam engine, by carrying the expansion of the steam to the furthest practical point, and thus utilising the maximum calorific power, that was a problem of great complexity, the practical solution of which had not hitherto been attained. It was thought that the apparent difficulties in dealing with ether should not be considered an insuperable obstacle to ultimate success. The present leakage at the joints required attention, as it involved waste of ether, and increased the chance of danger. There was no apparent reason why this should not be accomplished, as, although ether penetrated more readily than water, and thus necessitated a better joint, yet it was not a corrosive liquid, and had no appreciable action upon metals.

It was believed, that the right way of looking at this question was to compare the performances of the combined marine engine, first, with ordinary marine steam engines, made by experienced makers; secondly, with the most economical engines working on land; and thirdly, with a theoretically perfect engine. With regard to the first point, it was found that the use of the combined engine, setting aside the cost of the ether, effected a saving of two-thirds or one-half in the consumption of fuel. In the second place, 2 lb. of coal per I.H.P. (the ascertained consumption in the Kabyle), represented one hundred millions of duty in a Cornish engine, which was very good work,—many engines doing much less; therefore there was an engine used for steam navigation as economical in point of consumption of fuel as some of the best engines employed for pumping. The third comparison, that an equal amount of economy would be gained by a proper expansion of the steam at a low point, without the intervention of ether, might be answered by the fact that marine steam engines were still made which consumed at least one-half more fuel than those under the combined system. It should be borne in mind that where the practice was pursued of working steam very expansively, more fuel per indicated horse power was stated to be burnt than when working with full steam,—at all events, the expected economy was not produced. As regarded the question of the leakage of the ether, the waste was now so small, that it was commercially worth while to use it, and thus to effect a saving in the consumption of coals. The vapour caused little or no inconvenience. It was not simply whether the cost of the ether was equal to that of the coals saved, for the space which the coal occupied in the ship must be taken into consideration. The danger was not greater than was incurred in the use of gas in a dwelling-house, and no objection could be made to the system on that ground. An explanation was offered as to the reason why the system had not been employed in England. As an illustration of the difficulty of getting any new invention tried in this country, it was mentioned that an offer had been made to a large steam-boat company to apply the vapour engines to a vessel of 60 H.P. free of cost to the company. Their performance was to be tested on land, before being placed in the vessel; and if when fitted in the ship an economy of 25 per cent. was not obtained, then the ordinary engines were to be replaced without expense to the company. This offer was refused, the company giving as a reason that they did not like trying experiments. It had been stated that other fluids than ether might be applicable. The bi-sulphide of carbon was cheaper, gave more bulk of vapour, and was in every respect a more desirable vapour than ether. A description was then given of a modification in the method of effecting a junction between the wrought-iron tube-plate and the tubes of the vapouriser, which also acted as the steam condenser. When thus constructed it was proved with air pressure, and the loss was ascertained to be only 1 lb. per hour, so that it was practically tight.

Some remarks were then made to show how objectionable it was to work without a steam jacket to the cylinder, especially when using steam very expansively, as the cylinder then became a condenser at the commencement, and a boiler at the end of the stroke. Great credit was due to M. Du Trembley for introducing a system for concentrating the light pressure of the long end of an expansive figure; but it was not thought that any more power could be obtained from a given quantity of heat by this means than by the proper use of steam.

It was thought that the vapour engine should have been compared with a pumping engine, and not with an ordinary marine engine, as the actual efficiency of and the real duty performed by the latter could not be ascertained; whilst the load upon a Cornish pumping engine was a known and definite quantity. For comparison in respect to load, engines should be divided into three classes:—first, the Cornish engine, in which, with a known weight at the end of the beam, an effort was exerted in each succeeding stroke of similar and equal value. Secondly, with a factory engine, working with a load, which might be, but was not generally known. Thirdly, with a marine engine, in which the load on the engine could not be stated, as there were no means of determining or measuring the friction of the vessel. One of the chief peculiarities of the pumping engines, constructed on the Cornish principle, was the employment of a steam jacket around the cylinder, and in direct communication with the boiler, the cylinder being situated at a higher level than the boiler. It was now also frequently the practice to surround the jacket in addition with a coating of ashes twelve inches in thickness. The amount of benefit derived from the use of the jacket was capable of being precisely determined. It had been ascertained that the water, converted into steam to keep the jacket warm, amounted to one forty-fifth part of the whole quantity of water used as steam in the cylinder. In Cornish pumping engines the pressure of the steam in the boilers and the jackets was 35 lb., whilst on the

Digitized by Google

piston it never exceeded 25 lbs, and when working expansively it did not amount to more than from 10 lb. to 20 lb. In applying expansion to marine engines it was the custom to expect, in ordinary working with full steam, that there should be the same pressure on the piston as in the boiler. But if the same amount of effort was to be got in one stroke of an engine when worked expansively as when using full steam, then the initial steam must be considerably higher to allow to a certain extent for the cutting off.

It was urged that the true measure of the efficiency of an engine was the quantity of water passing through it, as steam, in a given time, and that the application of meters to engines would enable this to be ascertained with accuracy. This was considered preferable to recording the quantity of coals burnt; because when the duty with a given consumption of fuel was stated, that represented the degree of attention of the stokers, the quality of the coals, the construction of the boilers, and the perfection of the engine combined, and it was well know that the coals and the boiler might cause a variation to the extent of 50 per cent. in the quantity of steam generated. It was also contended that there was no practical value in the employment of ether, and that if high-pressure steam was used, expanded in a double cylinder engine, with proper precautions against radiation, equally economical results might be expected.

It was observed that the discussion so far had reference principally to the administration of steam in an ordinary engine rather than to the combined vapour engine described in this Paper. It had been said that high-pressure steam, used very expansively, would lead to as economical results as the ether engine; but it seemed to be forgotten that the latter was made the means of utilising the temperature of the exhaust steam, and that by this system, after the most favourable results had been obtained by the use of steam alone, a still further economy might be produced by the addition of the ether engine. It was the means of utilising 5° or 6° of temperature which were ordinarily lost, to boil another liquid to produce another atmosphere.

It was admitted that the arrangements of the combined engines were admirable, and the workmanship excellent, all the joints being apparently tight. The experiments on the whole had been made in a most satisfactory manner, and seemed to induce the belief that the difficulties still to be overcome were but few, that the danger was less than had been anticipated, and that the use of two liquids, evaporable at different temperatures, might hereafter be profitably introduced.

It was agreed that if ether was used in combination with steam, as in the Sahel, as much duty might be performed as with steam alone used expansively; but it was believed it could be shown theoretically that a higher performance could not be obtained. To boil ether the vacuum in the condenser of the steam cylinder must be reduced to 6 lb. or 7 lb. per inch less than in the condenser of an ordinary steam-engine worked expansively. Again, an inch of water would produce about a cubic foot of steam at the pressure of the atmosphere, but the same quantity of ether could only produce about one-eighth of a cubic foot of vapour at the same pressure. Therefore it was believed better results would be obtained by using steam expansively in a cylinder entirely cased with a steam jacket, and combining other recognised improvements.

Some recent experiments on steamboats gave the following results:

No.	Name of Vessel.	Absolute pressure of Steam on admission.	Rates of Expansion nearly.	Consumption of Coal per I.H.P. per hour.
		lbs. per square inch.		lbs.
1	Admiral	34	5	2·95
2	Callas	38	6⅔	2 7
3	Not yet named	63	8	1·88
4	Not yet named	106	15	1·018

It was observed that the last experiment was incomplete, as it had been stopped by a fog. In reference to the combined engine it was stated that theory showed that for a given initial pressure and temperature of steam the combined engine must be the more economical, because of its enabling a lower limit of minimum temperature to be reached, and diminishing the loss by overcoming back pressure and friction; but it appeared that by using a high enough initial pressure and temperature of steam, the steam engine could always be made equal or superior in efficiency when required.

It was thought that expansion in marine engines might be resolved into two considerations: first, could a pound of steam develope more power when used very expansively than when carried to the usual point of about three-fourths the length of the stroke before cutting off, as in the ordinary full-powered marine engine? Secondly, was the expenditure of coal per I.H.P. increased or diminished as expansion was extended? A series of trials, with H.M.S. Renown, Victor Emanuel, Algiers, and Racoon, showed that when only half the number of boilers was used and the steam was worked expansively, being cut off at 6·5 of the stroke of the piston, more than half the power was developed which was given out by all the boilers, though the excess was not considerable. As to economy of coal, it was stated that in H.M.S. Dee, with steam jackets embracing the cylinders, the consumption of fuel, when working at full power with common steam, amounted to 3·9 lb. of Welch coal per I.H.P. per hour. When the steam, after leaving the boilers at a temperature of 237°, had been superheated to 377°, the result was 2·74 lb. per I.H.P. per hour. In this case the steam was cut off at exactly half the stroke. It was found that when cut off at an earlier portion of the stroke the consumption of the fuel was immediately increased. The most economic result, when working at full power and with superheated steam, was 2·97 lb. per I.H.P. per hour. The advantage in horse-power by expanding beyond the half stroke was more than compensated by the increased consumption when working beyond that point in ordinary marine engines with steam of a pressure of 20 lb. It was of great importance that the mean temperature in the cylinders should be such as to prevent condensation. With regard to the use of high-pressure steam in marine condensing engines, it was observed that the difficulty with the Government gun-boats and block-ships, in which steam of a pressure of 60 lb. was employed, was to insure for any length of time the necessary tightness in the tube plates, whether of iron or brass. The consequence of any failure in this particular point was, that the ends not only of the leaky tubes, but of all those around them, became incrusted in a short time, and all the lower tubes were so plugged up as frequently to require boring tools to clear them. Surface condensation might have the effect of preventing this leakage and of obviating the incrustation of common salt and the closing up of the tubes, in which case the boilers would become like those of a locomotive engine.

It was said that the mechanical arrangements of M. Du Trembley's engine were fairly entitled to great praise. That engine presented a theoretical and practical advantage in utilising the waste heat of the condensing water, supposing the ether vapour to be eliminated, without the necessity of costly apparatus. But still it was felt that attention should first be directed to a system of perfecting the ordinary marine engine, rather than obtaining more favourable results by the addition of the ether system to the present engine. A marine engine, with proper adjuncts for using steam of from 45 lb. to 60 lb. pressure, precautions being taken to economise the heat at a high temperature, and the difficulties in the way of dry and rapid condensation being successfully overcome, would if the laws of heat and elasticity were to be believed, result in greater economy, with more safety, than was promised by the combined system. In such a case the consumption of fuel might be reduced even below 2 lb. per I.H.P. per hour, as the result of ordinary working, not of a series of short experiments, the results obtained from which could rarely be received or recognised as facts. When this economy was accomplished M. Du Trembley's system could, if it was hereafter thought desirable, be adapted to the then existing arrangements.

It was considered that the subject had been treated in the Paper rather in a commercial than a scientific point of view, and that the gross consumption of the fuel, as it had been taken, was a loose standard to adopt. It was argued that the combined vapour engine should not be compared with theoretical marine engines working at very high pressures, for whatever pressure was employed in the ordinary engine might be used in the combined system. It was shown from indicator diagrams, taken when high pressure was used, that the power of steam was equal to the power of the vapour of ether. It also appeared that whatever power was gained in the ether engine was so much deducted from the steam engine.

Therefore theoretically there could be no gain by the adoption of the combined system. But a practical advantage might result by reducing the consumption of fuel from 3 lb. or 4 lb. per I.H.P. per hour to 2 lb. per I.H.P. per hour. The present steam engines were constructed for fixed gases rather than for saturated vapour. One of the chief reasons why the combined engine was practically more economical than the marine engine was, that in the latter, when the steam was used expansively, there was a certain amount of condensation and re-evaporation going on in the cylinder, as had been previously explained. But if the heat of the cylinder was maintained, and its size was increased, this effect would disappear. To produce the most favourable results it was contended that the surface of the condenser should be equal to half that of the boiler.

In conclusion it was remarked that if the steam could be so expanded as to leave the cylinder at a temperature of only 60°, then there would be no advantage in the combined system; but it was difficult in a marine engine to have a cylinder sufficiently large for the purpose. From some experiments which had recently been made it was ascertained that the latent heat of ether was 175° Fahrenheit, equal to 97·3° centigrade. This result agreed nearly with the estimate given by M. Du Trembley, who stated it to be 96·12° centigrade. The difference might be accounted for by the apparatus employed and the process followed not being the same in each case. The former was deemed to be the more correct figure, and the mode in which it was obtained was described in detail. It was also found that the heat required to generate ether vapour was less than that necessary for eliminating steam in the proportion of 76 to 96.

After the meeting of February 1st, Mr. DENISON, Q.C., exhibited a small crab, or winch, capable of lifting half-a-ton with a single pulley, although light enough to be carried in one hand. It had two short barrels with five grooves in them for the rope, and a wheel at the end of each barrel, both of which were driven by equal pinions on the winding arbour. The rope passed from one barrel to the other; and the loose end was either pulled off by hand or fell by its own weight, or by the weight of the de-

Digitized by Google

ascending blocks, or empty bucket attached to it, if the crab was worked alternately like buckets in a well. This avoided the loss of power and increased strain on the wheels from the accumulation of rope on the barrel when worked in the common way, and the loss of time in fleeting, or passing the four or five coils of rope back from one end of the barrel to the other (which required special apparatus for it), and brought the whole machine into a smaller compass, with less weight than a common crab of the same power, because thinner and smaller wheels could be used, on account of the strain upon them being always uniform in lifting any given weight, and because the barrels need not be longer than five times the thickness of the rope.

Several members stated that the machine was a very good one, but it had been invented long ago, and was now in use in many factories. To this it was replied, that it was surprising that so valuable an improvement of such a clumsy machine as the common long-barrelled crab, should have been unknown to the various engineers, builders, and other persons conversant with such matters, to whom it had been shown or described. It was found that the time spent in fleeting the chain was no less than a quarter of the time spent in actually lifting the Westminster bell to the top of the tower, and two crabs were used for it; whereas with one such machine as this it could have been lifted the whole 201 feet without any interruption. Some persons to whom it had been described, before they had seen the present machine in action at Mr. Dent's clock factory, doubted whether it would answer; some said it was just what they wanted; some were surprised that it had not been invented before; but not one of them appeared to have had the least idea that it had not only been invented before, but that it was in common use, as was now stated. The only object in bringing the machine to the Institution was to make it generally known, and to show its convenience, and it was hoped that the present conversation would assist in doing so, as it probably would, even more completely than if the invention had been really new and comparatively untried. There were some details of construction for diminishing friction in machines of this kind, which would be gladly explained to anyone who might think it worth while to inquire about them, as they might not occur to everybody who merely set to work to make such crabs from the general description which had been given.

At the meeting of February 22, some specimens of timber recently imported from the north-west coast of America, were exhibited by Mr. G. R. BURNELL. It was observed that the quality and dimensions of this timber, which came from near Vancouver's Island and the district bordering upon British Columbia and California, appeared to be such as to justify rather more than the passing notices hitherto given in the technical journals of the metropolis.

There were now lying in the Commercial Docks between fifty and sixty logs of this timber, upwards of 100 feet in length, and measuring at least 22 inches on a side. There was one log in particular which was 129 feet long, die square, perfectly straight and sound, apparently free from dead knots or shakes, and measuring 39½ inches on the side at the middle of its length. At the butt end it was nearly 4 feet square, and at the taper end it was about 2 ft. 4 in. square; and it contained 1302 cubic feet, or upwards of twenty-six loads.

No experiments had been made on the specific gravity or on the strength of this timber; but from the manner in which it floated, it would appear that its specific gravity was about the same as that of yellow pine. The strength would appear to be equal to that of the best crown Memel, if an opinion might be formed from the way in which some planks had been bent, and the conditions of elasticity indicated under such circumstances.

For bridge-building, roofing, and scaffolding purposes it was suggested that this North-western American fir would be of great value on account of its length and its remarkably uniform character.

Some light spars of the same kind of wood, about 119 feet long and 15 inches diameter at the butt end, had also been imported from the same coast.

The price of the very long spars was at present about six shillings per foot cubic; this was high, but no doubt it would hereafter be diminished. The price of ordinary lengths was nearly the same per foot cube as that of the best crown Memel deals.

Attention was directed to the number and closeness of the annular rings, which indicated that the trees were of slow growth; and it was thence inferred that the wood would probably be durable.

It was suggested that it would be desirable to make some experiments of an authentic character on the properties of this timber.

March 1.—The Paper read was "*On the Co-efficients of Elasticity and Rupture in Wrought-Iron, in relation to the volume of the metallic mass, its metallurgic treatment, and the axial direction of its constituent crystals.*" By R. MALLET, M. Inst. C.E.

It was assumed that amidst the numerous theoretical treatises upon and practical investigations into the strength and other properties of iron, the two questions which formed the prominent features of the author's present experimental inquiry had remained comparatively untouched. The conditions of manufacture and the resultant qualities had been hitherto too lightly passed over.

Iron was formerly entirely worked under tilt hammers; the process of rolling was then introduced, and now, in consequence of modern engineering requirements, masses of iron of considerable magnitude were produced by faggoting together, under heavy forge hammers, from large numbers either of bars or slabs grouped together. The masses were not however found to possess ultimate strength in proportion to the number of bars of which they were composed; in fact it appeared that the strength of the mass became less in some proportion as the bulk became greater. This was admitted as a fact, but no one had hitherto attempted to show experimentally — what function of the magnitude was the strength of a given kind of iron manufactured in a given manner; or how the same forged mass, when very large, differed in strength in different directions with reference to its form; or how the mechanical part of the process of manufacture of the same iron affected its actual strength, either as a rolled bar or a forged mass.

Addressing himself to this investigation the author dealt generally with three points of the inquiry, viz.—

1°. What difference did the same large bars of unwrought-iron afford to forces of tension and of compression when prepared by rolling, or by hammering under a steam hammer?

2°. How much weaker, per unit of section, was the iron of very massive hammer forgings than the original iron bars of which the mass was composed?

3°. What was the average or safe measure of strength, per unit of section, of the iron composing such very massive forgings as compared with the acknowledged mean strength of good British bar iron.

In the investigation of these questions other subordinate but very important points arose: such as the determination of the relative longitudinal and circumferential strength of equal sections of the iron in massive cylindrical forgings.

The proper measure of the strength of iron, or any imperfectly elastic material, was the "work done," whether by extension, compression, rupture, or crushing, due to any force applied to it. The co-efficients Te and Tr were designed by Poncelet to express this work done by an extending or compressing force upon any elastic prismatic body at the point where its elasticity became permanently impaired and its form distorted, and at the further point where rupture occurred. The method of arriving at these co-efficients was then given, and it was shown that, though they were were not sufficiently attended to in practice, yet that they were the true measures of the safe and ultimate resistance of materials, when applied constructively in machines or otherwise.

The crystalline structure of iron was then considered, and quoting from the author's communication to the Royal Irish Academy (*Trans.* vol. 23, p. 1, 1855), it was shown to be a law that "Iron, whether in the state of cast or of wrought iron, has the principal axes of its integrant crystals arranged in the lines of least pressure within the mass."

If consolidation from fusion took place undisturbed, as in cast iron, the principal axes would be arranged in the directions in which the heatwave had passed outwards from the body in cooling; which would be perpendicular to its surface contour,—those being the directions of least pressure of the internal constraining forces, produced by contraction in cooling, which were necessarily parallel to the planes of external contour.

The effects of rolling and of hammering masses of wrought-iron of different contents were then treated of, and it was shown that what was termed "fibre" was the longitudinal extension of the principal axes of the crystals. The original development of these crystals under the constraining forces due to change of temperature, &c., was "cæteris paribus" proportioned to the time given for such development. Thus, in very large forgingsthe crystals were generally extensively developed, in consequence of the length of time which the mass had been under the operations of heating and forging.

It had long been admitted that large forgings became weaker in proportion as their bulk was increased, but as no definite ratio was recognised it became of importance to fix the conditions of strength in wrought iron under various circumstances. The author was enabled to undertake this investigation, under the authority of the Minister of War, and with the concurrence of the Royal Society, when making the forgings for the two 36-inch wrought-iron mortars constructed on his design for the Government; he then selected specimens of iron upon which the experiments of tension and compression were tried.

The methods were then explained by which the specimens of iron were obtained from large masses, and the apparatus was described by which the observations were made, when the specimens were undergoing the operations of extension and compression. In cutting and boring into the massive cylindrical forgings to obtain the pieces of iron from the various parts, it was invariably found that there existed internally large transverse rents, with jagged and crystalline irregular surfaces, the opposite faces of which were counterparts, and presented distinct evidences of having been torn asunder by contraction from the centre towards the circumference as the mass cooled. The *rationale* of the phenomenon appeared to be, that this action was simply due to the contraction of the external shell before the temperature of the centre had been perceptibly lowered; this in its turn was cooled, and in contracting produced these visible rents or fissures, and no doubt caused other minor dislocations which detracted from the general strength of the mass.

This was evidently the cause of the difficulty of obtaining very large

Digitized by Google

forgings of a cylindrical form quite sound; as if the diameter was sufficiently great all such cylindrical forgings so built in construction, and so treated by heating, hammering and cooling in manipulation, must become unsound internally by the opening within the mass of one or more of these rents in the direction of the axis during the process of cooling. In solid cylinders, or conic frustra, it must occur whenever the dimensions were such that the total amount of contraction of the metal in any one diameter from its highest temperature down to that of the atmosphere, as fixed by the circumference of rigidity due to the outer cold shell, exceeded the limit of extension of the iron at rupture due to the length of the diameter of the interior core, which cooled last. This was the theoretic limit of size of forging, beyond which internal rents must occur. The practical illustration was, that almost all cylindrical shafts of wrought-iron exceeding 12 inches in diameter were found to have one or more of these rents in them, thus having their strength impaired. This reduction of strength was altogether distinct from any deterioration of quality of the metal, arising from its being alternately heated and cooled and hammered.

The remedy for this play of molecular forces was to construct and work the large forgings hollow. This course had been pursued with success at the Mersey Iron-works, Liverpool. When a cylinder had a large concentric cylindrical hole along its axis it cooled at the same time, though not equally, on both the internal and external surfaces, and thus the extremes of internal strains were avoided, and the hollow centre yielded more readily to the forcible compressive grasp of the exterior.

A minute description was then given of all the irons which had been experimented upon, specimens of each being exhibited at the meeting. They were divided into classes according to their several characteristics and modes of working, and into the most analogous class was imported Clay's puddled steel, a comparatively new material, which had been brought into this investigation for the purpose of comparison, and the results were such as promised to be of great practical importance. The general results were the separation of the several classes into two grand divisions: 1°. The crystalline, or sub-crystalline in fracture, which were always the result of manufacture by the hammer. 2°. The fibrous, or crystallo-fibrous, which were always produced by the rolling process, but which might be produced by careful and continuous elongation under the hammer.

The very weakest wrought-iron of all those experimented upon was found to be that cut transversely from the end of a very heavy cylindrical forging which had been exposed to heat and percussion for nearly six weeks. Exposed to tension its elastic resistance was only 3¼ tons per square inch, which was less than the average of cast-iron; thus, as regarded pressure, it was the very weakest iron produced by any method of manufacture; whilst the faggot bars of which the mass was built and welded up bore a tension of upwards of 12 tons per square inch before losing their elasticity, and of nearly 23 tons at rupture, and a pressure of nearly 21½ tons before losing elasticity, and of nearly 27¾ tons at the point of total distension or crushing: thus proving the fact that the extreme weakness of wrought-iron in heavy forging was not due to any metallurgical alteration in the constitution of the metal, but to changes in its state of aggregation, induced by a process of forging, by the long-continued and unequal heating, and by the hammering.

Hence was deduced the conclusion, that practically the iron of very heavy shafts, forged guns, huge cranks, and other similar masses, might be expected to become permanently set and crippled at a trifle above 7 tons per square inch, and to give way by fracture at about 15 tons per square inch by tension, and to completely lose form at pressures of from 15 to 18 tons per square inch. Therefore it followed, that allowing a deduction of one-half, as sanctioned by practice, from the elastic limits of tension and of pressure for the margin of safety, the iron of such forged masses should not be trusted for impulsive strains exceeding about 1¾ ton per square inch of tension, and about 4½ tons per square inch of pressure, or for passive tensile-strains of 3½ tons per square inch, or for passive pressure beyond 9 tons per square inch.

Further experiments demonstrated that in heavy rectangular forged slabs of upwards of 12 inches in thickness, in the plane of the slab, the resistance to all the forces was much higher, and hence large cranks which were usually cut out of such rectangular forgings were stronger than the shafts to which they were attached, in the ratio of 8 to 6. The physical cause of the difference in strength between large cylindrical and rectangular forgings, although made from the same original material, was to be found in the difference of the molecular arrangement. The integral crystals of the cylindrical masses were strained, distorted, and partially separated by the effects of hammering in various directions, and by the peculiar constraining forces due to contraction in cooling; whereas none of these forces acted to the same extent upon rectangular masses, which were only hammered in three directions, and the constraining forces of cooling were all parallel to the faces of the parallelopiped, or in three directions only.

A special peculiarity noticed in heavy forgings was the sudden and extreme inequalities of texture and of strength found in different and even in closely adjacent portions of the same mass, producing greater uncertainty of result in practice.

Another peculiar feature was that the rates of extension or of compression did not move uniformly, but by fits and starts. This phenomenon obviously arose from the *per saltum* disintegration of planes of crystallisation, and their more or less complete separation in a crystallised but yet ductile body. This had never been observed in fibrous irons, or in those in which the finely elongated crystals were all rolled parallel and in the line of the length of the bar or the sheet.

If the original or integrant faggot bars, from which a heavy forging was built and welded up, had a tensile elastic strength of 12 tons per square inch, the forged mass itself would have a mean tensile elastic strength of only 7 tons per square inch; and correspondingly if the faggot bar had a compressive elastic resistance of 21½ tons, the forged mass itself would range under 18 tons per square inch.

Thus, within the limits of practice, the work of passive resistance sustainable by heavy forgings was about one-half that of the faggot iron from which they were manufactured; but at the ultimate point of rupture they gave a better result. Heavy forgings were also more trustworthy when exposed to tensile strains in direction of their length or to transverse strains, as in girders, which ultimately were resolved into longitudinal strains, than when subjected to twisting strains, as in shafts, or to direct pull across the direction of length.

These and other considerations induced attention to the apparently superior power of puddled steel to support the forces by which the ordinary forged masses of wrought-iron were fractured, especially as by the employment of smaller and lighter masses greater strength in shafts, &c. could be secured. One special peculiarity appeared to be that in the heaviest pieces of this material the internal structure was as fine and close in the grain as it was in the smallest bar. The elastic limit was above that of the best wrought-iron, and the elasticity was so much more perfect, that it might be trusted almost up the elastic limit of about 15 tons per square inch, and in forged masses it possessed this strength nearly equally in every direction. The range of extension at the elastic limit was rather greater than that of fibrous hammered bar iron of excellent quality. Beyond the elastic limit, with equal increments of strain, its extension did not rapidly diverge and increase, as in wrought-iron; it slowly increased up to about 20 tons per square inch, and gradually and evenly enlarged up to the breaking point, which was not reached within 42 tons per square inch, and was often found to reach 48 tons per square inch.

This puddled steel was not like cast steel, a harsh, rigid, and glassy material, which possessed indeed enormous cohesion, but yet was so rigid and unaccommodating to forces variable in direction and impulsive in character as to deprive it of trustworthiness in practice. On the contrary, puddled steel appeared to combine the great strength of cast steel with the ductility and perfect elasticity of the best wrought-iron. Its resistance to pressure was very remarkable, being more than double that of harsh crystalline wrought-iron, and more than three times that of the best fibrous wrought-iron in bars or plates. Thus it may be safely used under a passive strain or load of 20 tons per square inch, after allowing a margin of one-half for security.

Puddled steel would thus evidently become an important practical adjunct in the construction of machinery, in building vessels of light draught of water, and for artillery of the largest calibre. It possessed also the peculiarity of resisting corrosion much better than wrought-iron plates, and thus had an additional value for shipbuilding.

An investigation was then entered into of the causes of the manifestly greater strength of the integrant slabs than of the large forgings built up from them; but it was shown that this quality did not extend to the boiler plates, which acquired a certain amount of rigidity. This was also possessed by the puddled steel, and it was anticipated that it would ultimately be extensively employed for the boilers, and even the fire-boxes of the locomotive boiler.

From this investigation nothing of a certain character could be concluded as to any fixed relation between the strength and the specific gravity of the several sorts of iron experimented upon. The weakest irons—those from the heavy forgings—having generally the highest specific gravities, though always lower than their integrant faggot bars. Thus it appeared that specific gravity was a characteristic to which too great importance had hitherto been attached in relation to strength both in cast and in wrought iron. It was modified, increased, or diminished by the mechanical operations of manufacture to an extent far beyond anything that chemical difference of constitution produced, and in reality it afforded no criterion of strength, although in fibrous irons it did afford an index of their degree of extensibility for equal sizes.

The modulus of elasticity deducible from these experiments, from the mean results of the great forgings, was 12,559,680 lb., or 3,771,675 feet for iron forged in great cylindrical masses. The mean specific gravity being taken at 7663, the weight of 1 foot long by 1 inch square of this iron was 3·33 lb. The modulus for great forged rectangular masses or slabs was 18,079,200 lb., or 5,478,545 feet; the specific gravity being 7610, and the weight of a bar 1 foot long and 1 inch square 3·30 lb. Both fell far below the modulus for good English bar iron of 7,550,000 feet as deduced by Tredgold, or even below 6,787,878 feet as deduced by Edwin Clark from Eaton Hodgkinson's experiments.

The author concluded his Paper by recording the obligations he was under to Messrs. Horsfall and to Mr. Clay, of the Mersey Steel Works, Liverpool, and to the officers of the War Department and Royal Arsenal, Woolwich, for the facilities afforded to him during his investigation.

Digitized by Google

March 8.—The whole of the evening was occupied by the discussion of Mr. MALLET'S Paper "*On the Co-efficients of Elasticity and of Rupture in Wrought-iron*," &c.

It was explained that Tredgold and other experimenters only gave the absolute forces which would tear a bar asunder. In the present investigation an endeavour had been made to ascertain the amount of permanent elasticity possessed by the metal, as well as the point at which it would become actually ruptured.

It was contended that the drawings exhibited gave a very imperfect representation of the piling of the iron for large forgings, and that hence the author had been led to draw erroneous conclusions. With regard to the manufacture of the two monster mortars, 36 inches in diameter, and capable of throwing a ball weighing about 30 cwt., it was remarked that their merits as forgings were extraordinary At first, owing to large rents in the centre of the core, the forgings were failures, but after a little experience had been gained, the second forgings were quite successful. In the manufacture of these monster guns they were built up in seven distinct layers, the forging occupying seven weeks. So far from any deterioration or crystallisation taking place, the metal was improved by its long-continued heating and working; and the metal in the heart of the gun was found to be of greater strength than the bar-iron of which it was composed, being perfectly homogeneous, strong, and tough. A series of experiments for testing the correctness of the process showed that the ordinary manufacture of bar-iron, by working and re-working several times, had its limits. As a proof that the deductions in the Paper were incorrect, it was asserted that engineers had one universal rule for the manufacture of forgings, whether large or small, and it was not found that the shafts of 1000 H. P. engines were more liable to fracture than those of 100 H.P. This was practical evidence that the metal was not more deteriorated in large forgings than in small from the length of time it was exposed to the action of the fire; indeed no one portion was so exposed for any great length of time. It was urged that scrap-iron, or any other highly-refined iron, was the worst material for the construction of large forgings. It was considered that a strong fibrous fresh-puddled iron was superior in every respect, as the ordinary workings required in the process of forging would be sufficient to improve it to the average maximum of strength; whereas a highly-refined iron had already reached the highest point as regarded strength, so that it was more likely to be injured by additional working. There was another reason why scrap-iron should not be used for the manufacture of forgings. Scrap-iron was composed of many different qualities of iron, all having their own special welding points. When worked together, one portion which was less refined was too much heated, and consequently deteriorated before the more highly-refined portions were at a welding heat; so that there was the difficulty either of burning the one, or of being unable to weld the other. Again, the specimens selected by the author for trial, and which he said were weaker than the original iron composing the forging, were not taken off in the direction in which the fibre was laid for strength—in which it was intended that the strain should be borne. Now, forge-masters always laid the grain of the metal in the direction in which the strain would ultimately be applied; whereas the samples experimented upon had been cut transversely to that direction.

With regard to the new material, "puddled steel," it was believed that it was destined to work a complete revolution in almost all matters in which iron had hitherto been used. It had been proved to possess at least double the tensile strength of the best wrought-iron, and the elastic limit of the material was also greater in proportion to the breaking strain. A piece of this material had been subjected to a strain of 32 tons per square inch for seventeen consecutive hours without exhibiting the slightest appearance of elongation. Subsequently a bar 4 feet in length and 1 inch by $\frac{1}{8}$ths inch in section had been exposed to a strain of 45 tons per square inch, when it was found that an elongation of $\frac{13}{100}$ths of an inch had taken place. Upon the weight being removed $\frac{13}{100}$ths of this elongation were recovered, showing that the elasticity of the material had not been destroyed. On another occasion the elongation amounted to $\frac{24}{100}$ths of an inch, and returned to $\frac{20}{100}$ths of an inch. Upon a second application of a strain of 56 tons per square inch the bar was broken, the elongation having been $\frac{27}{100}$ths of an inch. In other experiments the bars broke at 55, 56, and 60 tons, and one bore the enormous strain of 87 tons per square inch. To attain this favourable result, which it was believed might eventually be accomplished as a rule, it was essential that great care should be taken in the selection of the materials, and great pains in the manufacture. It was entirely a question of good workmanship and good machinery; and a new manufacture of this sort would for years to come require the utmost attention and solicitude. In Germany, where this great improvement in metallurgy had been first introduced, a large number of manufacturers commenced making puddled steel; the consequence had been that an amount of bad material had been thrown upon the market, which had brought puddled steel into disrepute for a time, and from which it had scarcely yet recovered. This was to be feared in this country when the German patent had expired.

It was further contended, that if the calculations in the paper had been based upon forgings faggotted in the manner delineated in the drawings, they were of little practical utility. It was stated that large forgings weighing 20 tons, and measuring 24 inches in diameter, for engines of 1000 H.P., were now made at several places in England, without flaw or defect, except perhaps a small sand speck upon the surface, which was not of any consequence. When Nasmyth's hammer was first introduced, the plan was suggested of having the lower forge block made of a V shape, and the bottom part of the hammer so small as to strike only upon the upper centre of the periphery of the forged piece. The mass was thus struck in three places, and the tendency was to force the material to the centre, so as in fact to render the heart as solid and homogeneous as the other portions.

In reply to an inquiry as to whether the rents in large iron forgings, spoken of in the paper, would not also be liable to occur equally in the puddled steel, it was said, that in forgings of iron large crystals or grains were developed, which would not be the case in similar masses of puddled steel; and that in the latter the aggregation of grains or crystals was not increased by the agglomeration of the mass. These rents might be accounted for by the differential contraction of the metal. In the principal case referred to, the outside of the collar, which was 4 feet in diameter, cooled more quickly than the remainder of the forging, and these internal rents took place after it had left the hammerman's hand. It was stated that plates of puddled steel had already been supplied from the Mersey works for twenty-one vessels, some of them of 250 tons burthen and 38 feet beam. The thickness of the plates for the vessels for Indian river navigation was one-eighth of an inch, and none had yet been made, or called for as a mercantile commodity, of greater thickness.

In conclusion, a hope was expressed that on an early occasion the subject of puddled steel would be again brought under the notice of the Institution; for if it possessed the qualities ascribed to it, it was worthy of the most careful consideration of engineers, who had to design large railway structures, as well as for other purposes. In India and distant colonies, to which so much material had necessarily to be transported for public works, anything which would tend to reduce the weight to be carried, and consequently the freight, was a point of the highest importance. The Institution was therefore under great obligation to the author for having elicited this information.

March 15.—The paper read was "*Account of Experiments upon Elliptical Cast-iron Arches.*" By T. F. CHAPPE, M.Inst. C.E.

These experiments were undertaken at the request of Mr. W. H. Barlow, M. Inst. C.E., for the purpose of ascertaining practically the safe load to which elliptical cast-iron arches might be subjected, as well as the most economical distribution of the metal. The intrados of the arches was in all cases a segment of an ellipse, in order to obtain the greatest headway at the haunches. The experiments were, in each case, conducted upon two ribs, placed two feet apart from centre to centre, and resting on cast-iron abutment pieces, keyed-up tight against the springings. Diagonal stays and longitudinal struts were also introduced to prevent lateral motion.

The first experiment was made upon a model, one-fourth the real size, of one arch of a bridge intended to be erected over the river Trent, near Newark. The (model) arch had a clear span of 14 ft. 6 in., and a rise of 16 inches; a camber of $\frac{1}{4}$ of an inch being given in fixing the halves together. The sectional area of the arch at the crown was 2·43 inches,—that of the curved rib near the springing 2 inches,—about midway between the springing and the crown 1·75 inch, and of the spandril 1·34 inch. The weight of each arch was 1 cwt. 2 qrs. 22 lbs.

The other experiments were made upon a model one-sixth the real size of an arch erected over the Gloucester and Stonehouse and Great Western Railways, at Standish, six miles from Gloucester. The dimensions of the model were—span 13 ft 10$\frac{3}{4}$ in., and rise 1 ft. 10 in. The sectional area at the crown was 1·25 inch, of the curved rib near the springing 1·055 inch, about midway between the springing and the crown 0·993 inch, about the middle of the upper rib 0·883 inch, and of the spandril 0·57 inch. The weight of each arch was 3 qrs. 26 lbs.

The following pressures were given as those to which the arches were subjected in these experiments:—

Experiment.	Ultimate load.	How distributed.	Pressure per square inch of sectional area.	
			At crown.	At smallest section.
No.	Tons. cwt.		Tons.	Tons.
1	30 10	Uniformly.	8·52	11·83
2	18 0	Ditto.	6·80	8·58
3	12 0	Partially removed from the haunches.	4·54	5·72
4	5 0	On one haunch.	2·36	2·98
	3 12	At centre.	2·93	3·70
5	3 14	Ditto.	3·00	3·85

In the first experiment the ultimate pressure was not reached. In the second and third experiments one half arch was out of line laterally, beyond what would be permitted in practice, and was wanting in that

Digitized by Google

assistance which would have been afforded in the number of ribs required for the width of a bridge, so that the ultimate pressures indicated were below what such arches might be estimated to bear. This was also the case in the two last experiments, in which the castings were faulty, and the tests were such as were not likely to occur in practice. It was thought that cast-iron arches of the form experimented upon might safely be considered capable of bearing a pressure of between 8 and 10 tons per square inch of section. From the position of the fractures it was believed that the spandrils were too weak in proportion to the size of the arches.

The communication was accompanied by several tables, showing the deflections on the application of the different loads.

March 22.—The Paper read was on "*The Water Supply for the City of Melbourne, South Australia.*" By M. B. JACKSON.

The city of Melbourne was described as being situated on the north bank of the Yarra Yarra river, at a distance in a direct line of two miles from Hobson's Bay. The population was in December 1857 nearly 95,500 souls, for whose use the supply of water was very inadequate, not exceeding 3¼ gallons per head per diem, at a cost of not less than £105,000 per annum.

The city was built partly on a clay slate rock, and partly on a basaltic rock, or trap formation, the highest point near Carlton Gardens being about 148 feet above the river Yarra, whence numerous schemes were proposed for deriving a supply of water.

About the year 1845, Mr. Patrick Reid proposed a scheme of obtaining a supply of water for the city by means of a water wheel, to be worked by the falls; but the expense was considered to be too great.

In 1850, Mr. James Blackburn erected a small steam engine, by which water was pumped up into a tank, whence it was distributed by means of water carts.

In the same year Captain Cole suggested a somewhat similar plan, which, from want of encouragement, was not carried into effect. About this time, Mr. J. C. King proposed to supply the city from the Yarra, by a tunnel through the hill near Dight's falls, and using the water of the river as the motive power. This project on being referred to Mr. Blackburn, then town surveyor, was not approved of. It however had the effect of calling Mr. Blackburn's attention to the subject; and this induced him to recommend the river Plenty as a source for the water supply. In August 1851, he reported that this source was capable of providing for the wants of twenty thousand inhabitants, at an average daily supply of 40 gallons per head. This quantity, which was much too large for merely domestic purposes, included the supply for watering the streets, irrigating gardens, cleansing the sewers, and all other urban wants. The water, which was purer and softer than that of the Yarra, was to be derived from the Mount Disappointment range of granitic hills, whence there flowed a number of streams, which when united after passing through the swamps, formed the river Plenty. This scheme met with general approbation, but it was not at the time persevered in.

In 1852, Mr. Clement Hodgkinson proposed to obtain a supply from the Yarra by means of steam engines; and in this year Mr. James Oldham reported favourably on Mr. Blackburn's Plenty scheme, recommending the employment of iron pipes, instead of an open acqueduct, for bringing the water into the city.

In January 1853, a select committee of the legislature also reported in favour of Mr. Blackburn's plan, but advised a more careful investigation of the subject, by a commission of four non-professional gentlemen. In June of that year, these commissioners requested several engineers, among whom was Mr. Jackson, to report to them on the subject. This resulted in the appointment of that gentleman as engineer to the board. A more careful investigation was then ordered of the locality of the Plenty river, and finally, in October 1853, it was decided to adopt that river as the source of water supply for twenty thousand persons, at a daily rate of 30 gallons per head.

Mr. Blackburn was appointed consulting engineer, and up to the period of his decease in 1854 the utmost cordiality and unanimity existed between him and the author, to whom the execution of the design was confided.

The Plenty river, as was previously stated, derived its water from several streams rising in the Mount Disappointment range of granitic hills; whence, after traversing the large swamps, they united at a spot a short distance from the intersection of the upper aqueduct with the stream. The total estimated area draining directly into the river was about 40,000 acres, and the quantity of water delivered from the hills was at the driest seasons about 5000 gallons per minute; but at least 40 per cent. of this was lost in the passage through the swamps. The evaporation was estimated by the author at 4 feet 9 inches per annum, and the mean rain-fall at upwards of 32 inches per annum.

The works were commenced at the junction with the Plenty river, by cutting the water-course in a northerly direction towards the Yan Yean reservoir, to reach which a tunnel of 440 yards in length was driven through a ridge of hills; the prevailing stratum being clay slate, which would not resist the action of air and water, unless it was lined with hard basaltic rock paving. This water-course also served to drain the district through which it passed, and augmented the area of the gathering ground.

The Yan Yean reservoir was formed by throwing an embankment across a valley between two spurs of hills, and thus retaining the rain and flood-waters within it. The area, when full, was 1303 acres, and the average depth was not less than 18 feet, giving a cubic content of 38,000,000 of yards, or upwards of 6,400,000,000 gallons.

The area of the natural catchwater basin of the reservoir was 4650 acres, which would give, independently of the Plenty basin, but inclusive of the water-course, a drainage area of 5250 acres, and to this great additions might be made, by drains cut into the slopes of the adjoining hills.

The embankment of the reservoir was 1053 yards in length at the top, and 30 feet high at the deepest part; the general top width was 20 feet, with an inner slope of 3 to 1, and an outer slope of 2 to 1. The inside was finished with rough pitching from 15 inches to 20 inches deep, with an unusually thick puddle trench, which latter was adopted on account of the clay being easily procured, and because the grubbing up of the long straggling roots of the gigantic trees, formerly occupying the site of the reservoir, might have made clefts in the soil which it was desirable to close up hermetically; added to which there was difficulty in securing conscientiously good work in the colony, after the discovery of the gold fields.

The three inlet and two outlet pipes, each of 33 inches in diameter, were contained in a well tower at the foot of the inner slope, and on the outer slope there was another tower and valve chest, with a main of 30 inches diameter. This arrangement was made in order to secure the supply of the city, at times, by means of a compensation pipe, while the inside tower was undergoing cleansing, and also to get rid of any air which might otherwise interfere with the circulation.

The pipes of 33 inches diameter put through the embankment were, in order to save time, cast at Sydney, and when the reservoir was finished and was partially full of water, the author was informed by one of the workmen that two of these pipes at about the centre of the embankment had been fractured for a long time. The water could not be drawn off by means of these pipes without great hazard; so it was resolved to prepare a series of cylinders 2 feet 6 inches long, having an outer diameter of 32⅜ inches and made of boiler plate ⅛ inch in thickness. These were passed seriatim up the main pipes, made fast by wedges of hard wood, and well caulked with iron cement throughout the entire length of the main pipes within the puddle trench and the aprons. This was the only important casualty which occurred during the progress of the work; and there is every reason to believe that the remedy was perfectly effectual.

A description was then given of the course of the water from the reservoir by the main of pipes 30 inches in diameter, carried across gullies on stone piers, and over the river Plenty by a stone bridge. At a distance of 560 chains from the reservoir, the diameter of the main was diminished to 27 inches, which was continued as far as the pressure regulator,—a distance of 623 chains, and thence a main of 24 inches descended into Melbourne. The pressure regulator, which was manufactured by Messrs. Guest and Chrimes, was adopted in consequence of the author's proposition to introduce a valve, in order to diminish the pressure on the lower portion of the main, and his opinion that filter beds were not necessary. The adoption was sanctioned by Mr. Wm. Fairbairn, who acted as agent in England for the commission, with power to alter or modify anything which appeared to him desirable. When these machines were first set to work fractures of the main pipes repeatedly occurred, in consequence of the concussion or recoil on closing the valve. This was ultimately remedied by fixing air and safety valves on the pipes; but the author could not recommend the general adoption of these regulators. Disc valve regulators were also tried; but the author was of opinion that, "despite the beauty of the theory," he was "not prepared to recommend their use for large mains."

Reverting to the system of delivering the water to the city, the regulators, valves, pipes, means of crossing streams, gullies, &c., were described; and it was evident that the author had provided amply for all present contingencies and future extensions of the place.

The distribution of the water commenced at about 19 miles distance from Yan Yean, and at present there were (including these 19 miles of main) about 104 miles of pipes laid, varying from 24 inches to 3 inches in diameter.

In all the streets of more than one chain in width, a main of pipes was laid on each side, whilst in those under that width, the pipes were laid in the middle of the street. All the pipes were 9 feet long, and with the old spiggot and faucit joints. The service pipes were of lead, lined with tin. There were seventeen hundred of Bateman's fire-plugs, and the hydrants were manufactured by Messrs. Guest and Chrimes, a quantity of vulcanised india-rubber hose being also provided. The saving of property in cases of fire had proved to be enormous, and the rates of insurance had fallen 40 per cent. since the establishment of these water-works.

The gross cost of these works was stated to have been 664,452*l.* 1*s.* 2*d.*, but that sum included several large items which would eventually be charged to other works,—so that the net cost up to 1st January 1858, should be stated at 571,816*l.* 17*s.* 3*d.* These works were commenced in December 1853, and were completely opened for public use in December 1857.

Digitized by Google

A compulsory rate was to be levied, for meeting the interest of this capital, and to form a sinking fund for redeeming the capital. During the period of the execution of the works, the rates of wages were—masons, 36*s.* per day; labourers, 13*s.* to 20*s.* per day.

A series of appendices contained reports of the analysis of the waters, and statements of the rainfall and evaporation in various localities, and the Paper was illustrated by drawings and diagrams.

After the meeting, Mr. J. G. AUSTIN explained a "*Double Off-set Plotting Scale*," for the use of civil engineers, land surveyors, &c.

The invention was described to consist in the projection of the line upon which the plotting was to be performed, at a distance from the edge of the scale, by means of the station pointers, so as to admit the smallest off-set being plotted on either side of the scale.

The instrument was readily affixed to the paper and board, by placing the station pointers upon the line to be plotted upon, keeping the scale in use always on the left hand, and the lower pointer exactly at the station from which the line proceeded. Then, by turning the milled-headed screws at each end, the instrument was fixed immoveably during the operation of plotting. Should the length of the line exceed the capacity of the scales, the distance plotted must be denoted on the map, the instrument released by reversing the screws, shifted forward, refixed, and the work continued; but should the line be shorter than the capacity of the scale, the position of the instrument could be determined by the zero line of the off-set scale, without the necessity of extending the line to the length of the instrument.

The scales could be adapted to suit the operator, could be made of any material in customary use for such purposes, or the principle could be adapted to any existing scales.

The off-set scale was intended to traverse between the edges of the lateral scales, and the distance upon the line was to be determined by the edge, and the off-sets plotted on either side of the zero line.

The instrument was said to be simple in its use, to save much time in the operation of plotting the details of railway and general surveys, to insure accuracy, and avoid the possibility of error from shifting, and as the surface to be plotted upon could be seen, it enabled the smallest off-set to be denoted on either side of the line with greater ease and correctness than by the customary mode.

THE DESIGNS FOR THE NEW TABERNACLE FOR THE REV. C. H. SPURGEON.

THE following is the result of the competition:—The first premium of 50*l.* has been awarded to Mr. E. C. Robins, of 19, Arundel Street, Strand. The second premium of 30*l.* to Mr. W. W. Pocock, of Knightsbridge. The third premium of 20*l.* to Mr. Hill, of Leeds.

Mr. Pocock, the author of the design marked "Metropolitan Artist," to whom the committee have awarded the second premium, has also been appointed the architect to the new building.

We have been favoured with a copy of the letter announcing to Mr. Robins the decision of the committee, to which we feel great pleasure in giving publicity. In our own opinion, the *first* prizeman should have had the privilege of amending his plan in preference to the second, especially since the former is most in accordance with the instructions issued by the committee. It will be recollected that our last volume contained illustrations and descriptions of some of Mr. Robins' executed works,—we refer to Springfield House, and the enlargement of Dr. Cumming's schools adjoining his church.

"Dear Sir,—I am requested by the committee to forward the enclosed cheque for 50*l.*, as the first premium. In so doing, allow me to congratulate you upon the architectural taste which is so manifest in your drawings. In my own personal selection, yours was one of three which I considered to be pre-eminent among the many. We have inspected the designs with great care and long deliberation, and although we are compelled to prefer Mr. Pocock's design as the best basis for our future building, we could not but regret that we were thus compelled to lose your services in the erection. You may not be aware that we have received from private friends of yours, and persons for whom you have erected buildings, the most flattering testimonials of your ability. Since these were unsolicited on your part, and probably unknown to you, we thought them worthy of the highest consideration, and should have felt great pleasure in entrusting our great undertaking to your hands.

I am, &c., C. H. SPURGEON."

"To Mr. E. C. Robins.

RECONSTRUCTION OF SUNDERLAND BRIDGE.

THE original bridge, one of the earliest and most celebrated examples of cast-iron bridges of large span, constructed by Mr. Burdon in 1796, over the river Wear, for connecting Sunderland and Monkwearmouth, consisted of six cast-iron arched ribs, forming an arc of a circle of 237 feet span and 33 feet rise, with a clear height of 99 feet above low water; the ribs were of very light and open construction, only 5 feet deep throughout and 4 inches thick, fixed at 6 feet distance apart, and connected together by hollow pillars of cast-iron placed horizontally; each rib was constructed in separate short segments, 2 ft. 4 in. long, connected together by six continuous longitudinal wrought-iron bars, 3½ inches deep and ¾ inch thick, let into grooves on each face of the ribs and secured by six bolts in each segment. In consequence of the insecure and inconvenient condition of the bridge, an Act of Parliament for repairing it was obtained in 1857, and the works were commenced early in 1858. The most important defect of the original structure, was the absence of diagonal bracing; which, although in some measure rectified by an ingenious application of cast-iron crosses between the ribs, by Mr. Grimshaw of Sunderland, had still allowed of the whole of the ribs becoming curved laterally out of their vertical planes to the extent of as much as 16 inches. The bridge is now being strengthened by the addition of three wrought-iron rectangular tubular arches, of the same curvature as the cast-iron ribs, and 5 ft. 2 in. deep by 6 feet wide; the top and bottom plates being ½ inch, and the vertical sides ⅜ inch thick. These tubes are fixed in the alternate spaces between the original ribs, the old bracing being removed, and the ribs securely bolted to the tubes, so as to cause the whole to compress together, the original external form of the ribs being thus preserved; and in order to secure a perfect diagonal bracing at all points, the arch tubes are connected together throughout at the top by a boiler plate ⅜ inch thick, flush with their upper surfaces. The inclination of the road over the bridge on each side is also improved from about 1 in 17 to 1 in 50, by raising up the spandrils of the arch over the haunches; and the width is also increased about 10 feet by causing the footpaths to project on cantilevers. The reconstruction of the bridge is under the direction of Mr. Robert Stephenson, C.E.

SUNDERLAND NEW DOCKS.

THE hydraulic machinery which has been lately constructed by Mr. Armstrong for opening the large sluices employed for scouring the channel at the south outlet, and for working the dock gates and large drawbridge, is worked by an accumulator having a ram 2 feet diameter and 17 feet stroke, loaded with a weight of 100 tons, giving a working pressure of 495 lb. per square inch, charged by a 30 horse power horizontal pumping engine. The sluices are in two sets of four each, situated on each side of the outer gates, each sluice having an opening of 8 ft. 10 in. width and 7 feet height; they are rapidly opened by means of the hydraulic pressure, requiring only about half a minute, and open a total area of 495 square feet, which is done at low water, causing the sudden rush of a large body of water from the higher level within the gates, which effectually scours the entrance channel, and keeps it open to the sea. The large drawbridge, which is 100 feet span and 14 feet wide, slides laterally upon rollers, and is traversed across the opening of the dock entrance by a pair of horizontal hydraulic cylinders 10 inches diameter with multiplying chains, working on one side under the projecting tail of the drawbridge that balances the overhanging portion; and the whole platform weighing 150 tons is then lowered down 16 inches on to a solid bed by means of a pair of vertical hydraulic cylinders 17 inches diameter, which serve to raise it again when the bridge has to be opened; the time of opening or closing the bridge is little more than a minute.

Cathedral of St. Denis.—M. Violet Leduc is actively engaged in the construction of the new vaults of the crypt of the Imperial Chapel of St. Denis, which is to become the mausoleum of the reigning dynasty. The clockwork of the northern steeple will be reconstructed.

Digitized by Google

SOLDER FOR ALUMINIUM.

M. Mourey has described to the Société d'Encouragement in Paris, a process which he invented for soldering aluminium. He adopts an ingenious device for this purpose. In the ordinary way to solder two metals or two pieces of the same metal, all that is necessary after having prepared the two surfaces which are to be brought together, is to cover them with solder and to heat them. This mode of proceeding does not succeed with aluminium. M. Mourey prepares each of the two surfaces with a first solder, an alloy of aluminium and zinc, and then interposes between the two surfaces thus prepared another alloy richer in aluminium. In this manner the first alloy adheres to the aluminium itself, and the second alloy to the first, and thus a perfectly solid and continuous whole is obtained.

The surfaces to be soldered are prepared by being smeared with a mixture of turpentine, balsam of copaiva, and lemon juice, then placed on hot coals, and into the parts where the soldering is to take place the flame of a gas lamp or self-acting blowpipe is directed.

Small pieces of an alloy of 6 parts of aluminium and 94 of zinc, are brought into contact with the prepared surfaces; these melt and adhere to the surfaces, being pressed against them by small tools made of aluminium. This operation is a rapid one; it requires, like any other soldering of this kind, a certain amount of care, but not more than in the hard soldering of copper. In each case a skill and knack are necessary on the part of the workman, as well as care in adjusting the temperatures, for the melting point of aluminium and zinc are scarcely 100° apart, and there is a fear whilst melting the solder lest the article itself should melt at the same time.

When the two surfaces have been thus prepared, they are brought together and kept in contact by iron wires, pincers, &c., as in ordinary soldering; pieces of the hard solder (80 of zinc, 20 of aluminium) are then placed at the points of contact, and the heat from a lamp is then applied, and the second solder melts, runs in, and adheres to the two layers of soft solder, and thus forms a strong joint.

The articles thus prepared are sufficiently strong and homogeneous to allow of their being reworked, and the joints will bear filing.

NOTES OF THE MONTH.

New Law of Patents relating to Ordnance, &c.—A Bill has just been brought into the House of Commons by the Attorney and Solicitor General and the Secretary for War, to amend the law concerning Patents for inventions with respect to improvements in instruments and munitions of war. It provides that the benefit of any invention for an improvement in instruments or munitions of war, may be assigned to the Secretary for War, and that the enactment shall extend to assignments already made. In case of an invention so transferred or assigned, the Secretary for War may certify to the Commissioners of Patents, that the invention should be kept *secret*. Where the Secretary for War has so certified, the petition for letters patent and all other documents are to be left with the Clerk of the Patents in a packet under seal for the Secretary for War, the packet to be kept so sealed or to be re-sealed with the seal of the Commissioners of Patents. The sealed packet to be delivered on demand by the Secretary for War or pursuant to any order of the Lord Chancellor. At the expiration of letters patent, the sealed packet to be delivered to the Secretary for War. Where the Secretary for War certifies after filing of petition, documents already filed to be put into a sealed packet and kept secret. Copy of provisional specification, &c. not to be sent to Scotland or Ireland, or published, but otherwise provisions of Patent Acts to apply. No *scire facias* to be brought to repeal any certified Patent. The Secretary for War may waive the benefit of this Act as respects any invention; and the communication of any invention for any improvement in instruments or munitions of war to the said Secretary of State, or any person or persons authorised by him to investigate the same, or the merits thereof, shall not, nor shall anything done for the purpose of the investigation be deemed use or publication of such invention, so as to prejudice the grant or validity of any letters patent for the same.

The Society of Arts.—The Society's Eleventh Annual Exhibition of recent inventions will be opened on Monday the 25th instant. The society intimate to persons intending to exhibit, that they should communicate with the Secretary of the Society of Arts as soon as possible, stating:—1st. The title of the invention. 2nd. Whether the article will be a model, drawing, or specimen. The articles must be forwarded to the Society's house, carriage paid. The days fixed for receiving them are Thursday the 7th, Friday the 8th, and Saturday the 9th instant. No articles will be received after the last of these days. Articles which have been included in previous Exhibitions of the Society of Arts cannot be re-admitted. Articles should be accompanied by a short but clear description of the invention, with a wood block (when possible) for illustration, and a reference to any publication in which the invention is described. All drawings exhibited must be framed. No charge is made for space, and the admission to the exhibition is free. The Council have arranged for two Conversazioni during the present Session; the first, on Saturday the 7th May, at the Society's house; the second, on Saturday 28th May, at the South Kensington Museum.

Brussels.—The restoration of the beautiful tower of the Hotel de Ville at Brussels has been completed in all its original richness. There is nothing now wanting but the twelve statues which are to occupy the niches, and which are expected to be placed in their destined positions during the spring. The restoration of the interior of the town hall is to be completed in the course of the ensuing year.

Patent Office Rules.—The following rules, in respect of communications from abroad and provisional specifications, have recently been issued:—I. In any application for a patent which is stated to be a communication, the declaration must state the name and address of the party from whom it has been received, in the following manner:—No. 1. When declaration is made in the United Kingdom, "that it has been communicated to me from abroad by [here insert name and address in full]."—No. 2. In other cases, "that it is a communication from A.B., a person resident at [here insert address in full]."—II. All provisional specifications must be written on one side only of each sheet. (Signed) FITZROY KELLY, A.G.; H. M. CAIRNS, S.G.

Bridge over the Rhine at Kehl.—These gigantic works are pushed on day and night with great vigour. As soon as night sets in the appearance of the Rhine is extraordinary, as the electric light on the Baden side of the river begins to illumine the work, leaving all the rest in a greater or less degree of obscurity. The sinking of the caissons, the dragging of the rivers, and the work of the steam-engines, go on without interruption, except at midday and midnight, when an hour's rest is allowed to the men.

COMPETITIONS.

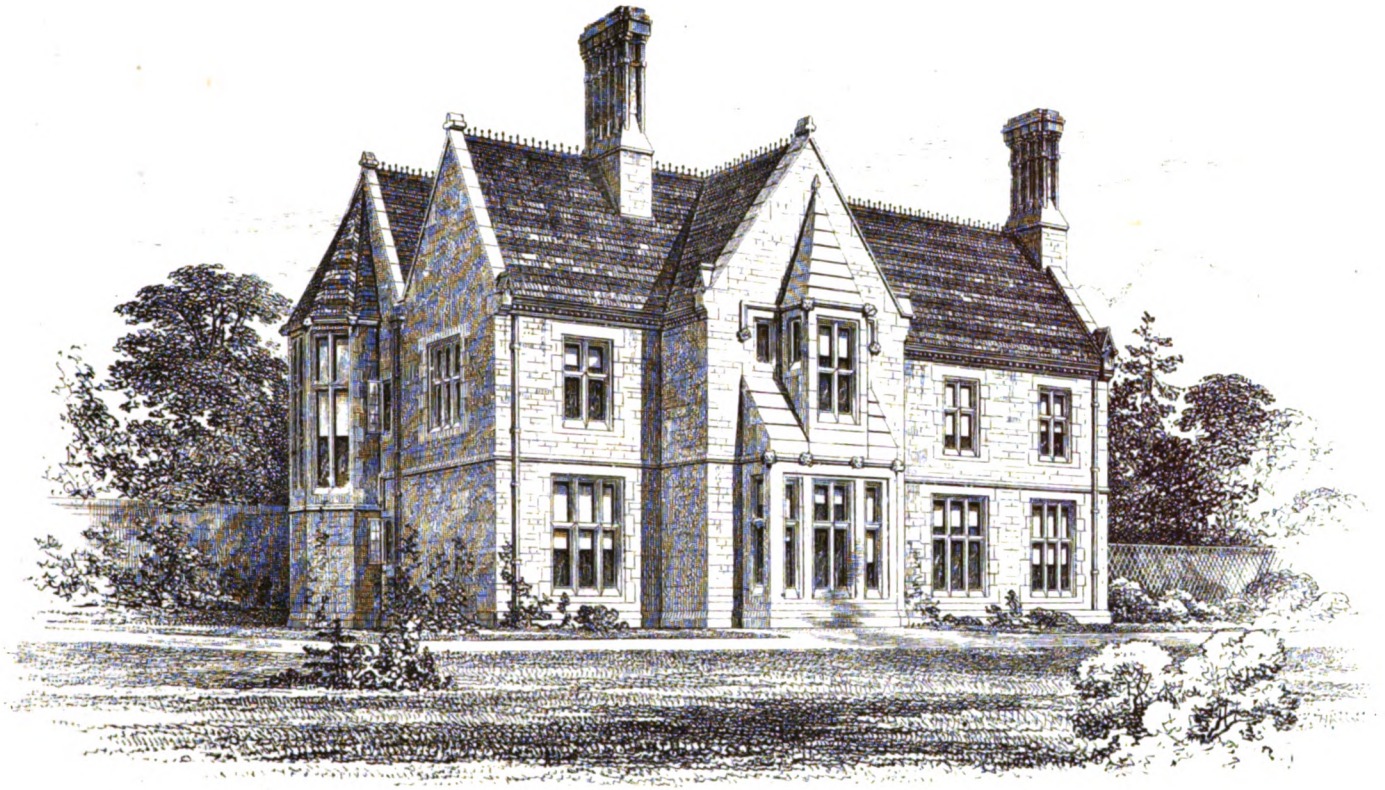
The committee for the erection of a New Infirmary at Ashton-under-Lyne are desirous of receiving Plans and Elevations, accompanied with a general description. The design to be based on a supposed outlay of £10,000, but the first outlay will not exceed £5000. The remaining £5000, and the extensions to be added at a future time. The elevation to be of stock bricks, with stone dressings of Huddersfield-stone; the passages and staircases to be fire-proof. Internal sanitary arrangements must not be sacrificed to architectural display. Efficient ventilation is specially desired. Premiums. £100 and £50. A plan of the site may be seen, and particulars obtained on application at the offices of Henry Thomas Darnton, honorary secretary to the committee. Designs must be sent in by the 30th instant.

The Winchester Diocesan Board of Education propose to build a Training School for fifty students, with apartments for principal, vice-principal, and matron. Architects are invited to send designs to the Rev. Canon Jacob, Crawley Rectory, Winchester, by the 11th of June next. The arrangements of the building must be such as to meet the requirements of the Committee of Council on Education; and the style simple, without more external ornament than is necessary to give it a distinctive character. The plan should admit of the erection of a chapel; and of additional dormitories and lecture-rooms for a limited number of students of another class, if required. The site has been secured, and should be viewed by architects proposing to offer a design.

Designs are required for the proposed new Jews' Hospital to be erected at Mile-end. Mr. Mocatta and Mr. Digby Wyatt have been selected as referees, who will award the three premiums of £100, £50, and £30 respectively. Particulars may be obtained on application to the Rev. O. P. Mendes, at the Jews' Hospital, Mile-end. Designs to be sent in by the 11th inst.

Digitized by Google

Digitized by Google

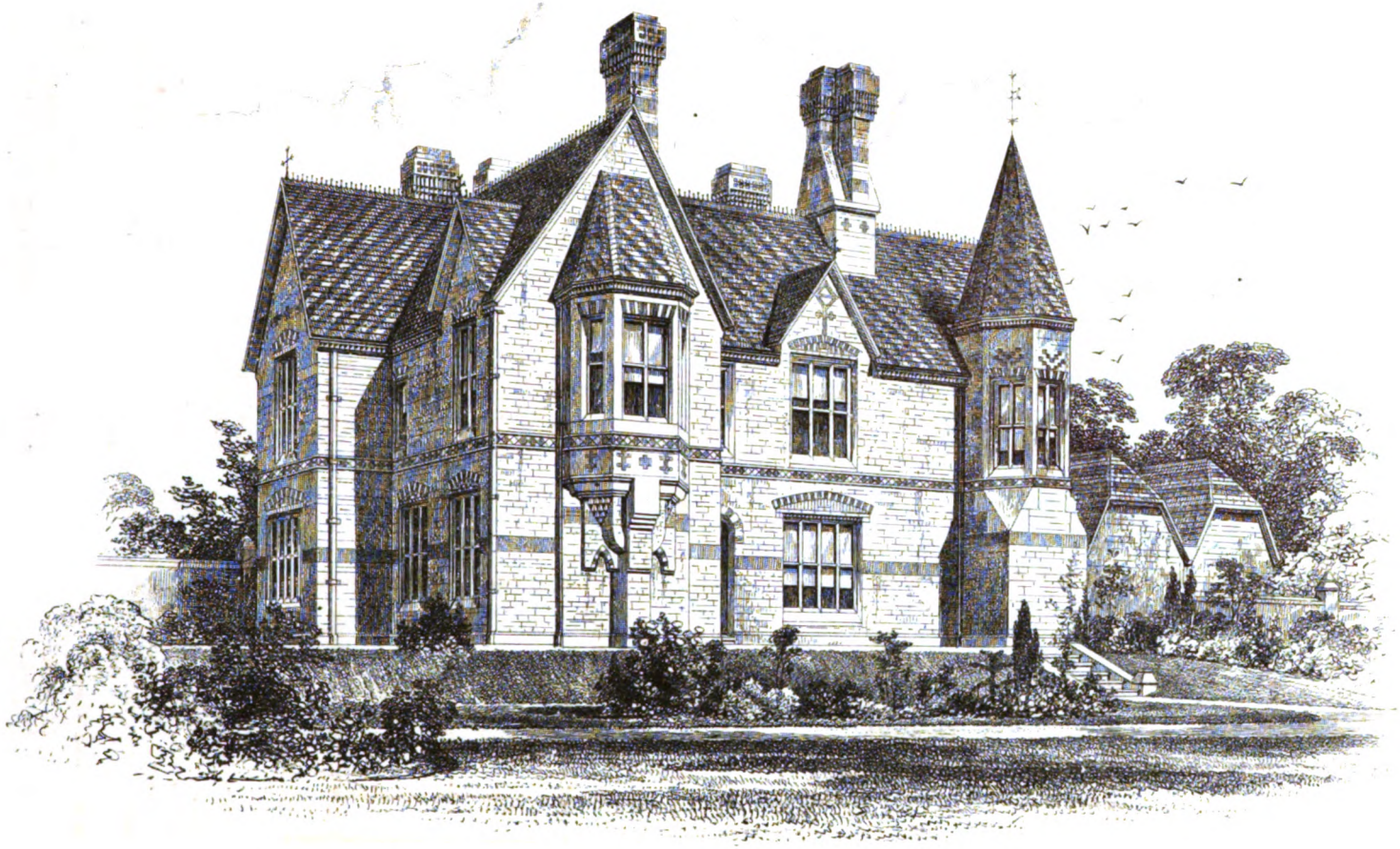


House erected at Birmingham 1856. Joseph James, Architect.

J.R.Johbins

Digitized by Google

Digitized by Google



House erected at Birmingham 1856. Joseph James, Architect.

June 1859

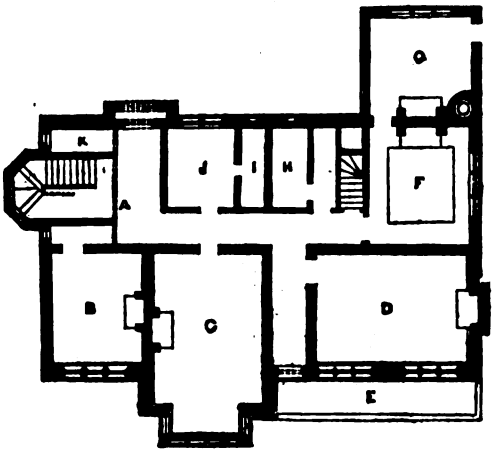
J.R.Johbins

Digitized by Google

SUBURBAN VILLAS, BIRMINGHAM.

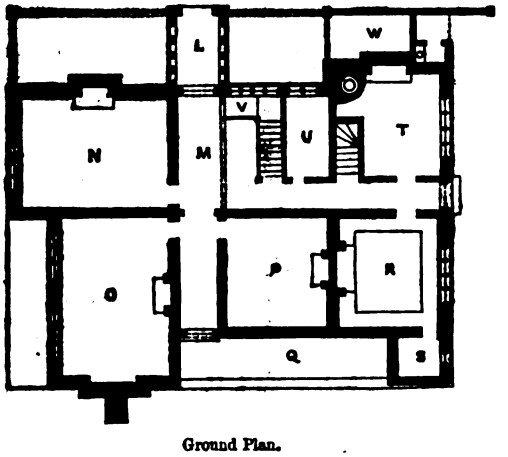
(With an Engraving.)

THE two villas illustrated in the accompanying engraving are both situated at Edgbaston, near Birmingham. In their design it has been the aim of the architect to secure that simplicity of which old work furnishes so many examples, and to avoid that forced attempt at novelty of design which is too often discernible in buildings of this class. The material employed is red brick; in the one case relieved by Bath stone dressings, and in the other by blue bricks and tile bands, judiciously arranged in patterns. The roofs are covered with blue and brown Staffordshire tiles laid in courses.



Ground Plan.

On reference to the accompanying plans it will be seen that they are so designed as to render the entrances as distinct as possible from the principal rooms. The interiors are handsomely finished. Brass furniture and gas-fittings of appropriate cha-



Ground Plan.

racter were supplied by Messrs. Skidmore, of Coventry. The hall is laid with Maw's encaustic tiles. The builders' work was carried out by Mr. Samuel Briggs, of Birmingham, under the superintendence of Mr. Joseph James, architect, Furnival's-inn, London.

Reference to Ground Plans.

A. Hall.
B. Morning room.
C. Drawing room.
D. Dining room.
E. Terrace.
F. Kitchen.
G. Scullery.
H. Larder.
I. Store.
J. China closet.
K. Hats.
L. Porch.
M. Hall.
N. Drawing room.
O. Dining room.
P. Morning room.
Q. Terrace.
R. Kitchen.
S. Larder.
T. Scullery.
U. China pantry.
V. Hats.
W. Coals.

THE ARCHITECTURAL EXHIBITION.

(SECOND NOTICE.)

We resume our examination of the architectural works in the Conduit-street Galleries.

Mr. C. F. Hayward, in his buildings, generally exhibits considerable fertility of idea, not always guided by the best of taste. He apparently labours too anxiously after novelty, and in consequence lapses into the error of crowding, and of excessive fancifulness. Proof of this we shall detect, more or less, in all the drawings he exhibits this year; in his domestic work especially, as may be seen in (64, 67, 69), all of which display good points, but are marred by the fault we are complaining of. His "Gateway at Weeley, Essex" (90), in red brick, is an ungainly and over-wrought affair.

There is also, in the "Porch at Mr. Philbrick's residence" (67), a curious combination of wood and brickwork,—the brackets supporting the roof coming down upon the sloped weatherings of brick buttresses, and thus, apparently without any hold or footing, it suggests anything but true or sound construction.

In the "Mansion for A. Edwards, Esq., Balgay, Forfarshire" (70), Mr. Coe aims at adhering to old Gothic details and tracery more closely than is now usual. In some respects the advantage of this is evident, yet there is in the general mass a stiffness and repetition of parts, especially in the three bay windows, which is not germane to the real feeling of the style. We have seen more worthy productions from the same hand.

(74 and 75) exhibit, in some telling photographs, portions of the new street architecture of Leeds, as executed from the designs of Mr. Corson, and both are clever and original in their treatment.—See also (86, 87.)

It is impossible to say as much for the next picture, "The Llwyn" House, near Oswestry (76), which is also Italian, but over-pretentious in character. The most striking object in the view is the mass of chimneys collected in the centre of the building, and which, though well intentioned, are so clumsily managed as to overpower the rest of the design.

In Mr. Horace Jones' "Design for a Training College" (78), we see a very simple treatment of Gothic elements; the result unusually good and cleverly managed.

(80), we merely allude to as one of the drawings which disgrace rather than adorn the walls.

(81), Mr. C. H. Cooke's "Entrance Lodge to Bromsgrove Cemetery" has been already illustrated in our *Journal*, of March 1858, as also the Lich-gate (311).

The large Mansion designed by Mr. Blake (82), shows but little life or feeling. It is characterised by engineering more than artistic conceptions.

(83), "Buildings erected for the Working Men's Institute, Hartshill," is, as a whole, excessively bad (at least as here shown). Coloured materials are freely abused, not *used*, so that, whatever merit may attach to the elementary forms, it is more than counterbalanced by the gew-gaw style in which they are tricked out.—See also (98.)

A pleasant relief, after wandering so long among picture frames, is afforded by the five very choice specimens of paper-hangings, exhibited (84) by Messrs. Williams, Cooper & Co. The great strides which have of late years been made in the art of chamber decorations are scarcely more observable in anything than in the substitution of the more seemly *flat* colouring imprinted on the walls and carpeting, in place of the showy but absurd attempts at relief ornament which till lately was so much in vogue. While referring to this matter we may mention that in the farther gallery (190) is another series of the same kind, prepared from designs by Mr. Owen Jones, and contributed by Messrs. Trumble & Co. of Leeds.

(85) (96). "Portions of the Erections for the South Staffordshire Water-works, near Lichfield," by Mr. Adams, are plain and sensible-looking. They at once explain their purpose; and, as nothing more is attempted, the beholder is reconciled to their comparative plainness. The propriety of facing such an amount of surfaces with Staffordshire blue bricks may be questioned. The unrelieved colour is dull, heavy, and monotonous.

There is unquestionable ability shown in (88), Mr. Peacock's "Schools at Wandsworth," although the drawing is not so inviting in appearance as many. The parts appear to be nicely balanced, and attention to have been given to details.

(89). Messrs. Walton and Robson's "Design for a Town Hall" shows a building of Gothic (continental) character, of the plainest

Digitized by Google

possible kind, and treated in a novel and effective manner. The interior of the principal room has a good open-timbered roof.

Of Messrs. Habershon's Gothic works we regret that we cannot speak in terms of commendation. There is a prevailing line-and-rule appearance about them, and a coarseness of details that are foreign to the true principles of the style. The "Dispensary at Newport" (94), is an illustration of this; and (97), "New Public Rooms," is worse still. In (192) are some "Designs for Villa Residences," which also partake of these faults.

Redcar Church is a thoroughly Kentish old church, and has been very prettily rendered (95) by Mr. Beetholme.

Passing by (99), "The Palace of Art," which even with its full length quotations from Tennyson, remains mysteriously incomprehensible, we come to a pretty group, also by Mr. Beetholme, of "Pompeian Fragments" (100), delineated with taste and exactness.

Mr. Christopher exhibits a capital series of Sketches from abroad (103—107, &c.). They are evidently scrupulously accurate, and to this may be attributed perhaps a hardness of outline, which is not unfrequently observable. In (193) we have an impression of the engraving of the "Tower and Spire of Bow Church," reduced from Mr. Christopher's measured drawings, which obtained a medal at the Royal Academy, and which Mr. Le Keux has very faithfully rendered.

A Church, built in Kentish rag and Bath stone, "to hold 900 persons, with large schools in rear—cost, £3500," may be well left to imagination. Such, however, is the statement appended to (109 and 168), being respectively an Interior and Exterior of the New Congregational Church at Woolwich. The former is unredeemably bad, but the latter, considering the circumstances, has been made the most of. We engraved in our March number a view of a much better design by Messrs. Lander and Bedells, which here is exhibited in (161).

(112). "Fox Warren, Surrey," represents a large Gothic mansion, designed by Charles Buxton, Esq., M.P., a gentleman, we believe, who has devoted considerable attention to architecture. In the design before us the large uncusped windows, without mullions, look tame and unsatisfactory; indeed, the whole reminds one too much of the Strawberry-hill period of the art.

No. 116 is a drawing which will well reward examination, and deserves to have had a better place. It presents a number of suggestions for "saw-pierced brass-work," designed by Mr. W. G. Smith; these are in the best possible taste, and peculiarly adapted to the material intended, consisting chiefly of scroll-work and leafage intertwined, and simply perforated in the flat. Among the subjects thus ably handled are "Eve in the Garden," "The Passion," "St. George and the Dragon," and "Our Saviour Blessing Little Children."

Great Gallery.

The first catalogued work in this gallery is essentially Mediæval, and consists of "Sundry pieces of Painted Furniture," lately executed from the designs of Mr. W. Burges (120). These include "a nest of pigeon-holes," the subjects relating to architecture and the subsidiary arts;—"a bookcase and escritoire," the subjects being the history of Cadmus, and the various descriptions of writing;—"a sideboard," on which is portrayed the dispute between the Wines and the Beers;—"a wardrobe," with figures to represent Flax and Wool; and "a buffet," on which is a sculptured figure in allusion to the sun, through whose influence the other metals represented on the panels were anciently believed to have been produced. In all these is a curious mixture of antiquarian and artistic details. Both as articles of furniture and of ornament, while there is much to admire, it may be questioned whether there is not as much to regret; for, with all the evident pains that the designer has bestowed, and the unrestricted display of his exuberant fancy in gilding and colours, the results, taken as a whole, are not altogether pleasing.

(121) Does not strike us as by any means a desirable *restoration* of St. Margaret's, Westminster, as proposed by Mr. Ashpitel. Although in its present condition the church is far from being comely in appearance, that very peculiarity of ugliness is not in that situation without its advantages; and though its entire demolition has been more than once threatened, it may be hoped it will yet be allowed to survive. If it is destined to undergo the renovating process, we should be more reconciled by its assuming a purer expression of Perpendicular, than the debased ogee forms which are here introduced,—notwithstanding its close proximity to Henry VIIth's Chapel. But conceding our opinion, if need be, as regards the body of the church, the attenuated spire to be added to the tower, and which appears to be of open or panelled tracery, would be decidedly out of place in such a neighbourhood.

Mr. Norton's "Mansion at Nutfield" (123) is Gothic, plainly and sensibly treated; it has the advantage, here at least, of being planted on a spacious terrace, which preserves the architectural symmetry of the whole.

We have in a previous number described the restorations about to be effected in the central tower of Durham Cathedral, under the direction of Mr. Gilbert Scott, with Messrs. Walton and Robson as sub-architects. A large elevation of this tower (127) shows clearly what is proposed; the drawing is in simple outline, boldly touched in with brown ink.

(128), Mr. Hooker's "Frowswell House, Goudhurst," is a capitally managed alteration of one of those delightful old half-timbered houses which abound in the Weald of Kent,—the lower part being of brick, while the upper floors are of framed timbers, having the spaces between filled flush with plaster.

A peep at the old steeple of St. Nicholas, Newcastle-on-Tyne, with its curiously-poised spire, is always welcome; and Mr. Storey has, in (131), done justice to the subject.

A "House at Great Malvern" (132), by Mr. Webbe, is chiefly noticeable for its picturesqueness of groupings. It is in the English Domestic Gothic style, and is well accommodated to the irregularities of the site by a series of terraces, which contribute much to the generally good effect of the mass.

In (133, 134) we have two sketchily tinted interiors from "St. Nicolo dei Mendicoli, Venice," and "Como Cathedral," by Mr. Penrose, who in (324) exhibits the "Sacristy of St. Mark's, Venice." In these the effect only has been attained: it is in vain to look for details, which ought however always to be more or less expressed to render a sketch practically useful.

Mr. J. K. Colling is this year a bountiful contributor. Besides his careful drawings of the South Porch of West Walton Church (164), and the detached Tower of the same church (171),—two of the purest specimens of Early English now remaining. We have a view (317) of the New Picture and Sculpture Galleries which he is now erecting at Hooton Hall, Cheshire, for R. C. Naylor, Esq. The alterations at this mansion from Mr. Colling's designs have been in hand for several years, and some time since we gave a large illustration of the general design, which is in the Italian style. The material of the new galleries is white sandstone from the neighbourhood of Birkenhead, and there are introduced large panels of red sandstone, and smaller ones of polished red granite and serpentine. The total length of the galleries internally is 298 feet.

(135) Exhibits an interior view, and (151) an exterior and plan, of the Church now erecting at Hooton for the same gentleman, and by the same architect. It is in the Byzantine style; hence the prevailing lines in the plan, arches, windows, and roof partake of the semicircular form. The clerestory windows are doubled in each bay, and continued round a semicircular apse. There is a western porch, with a large rose window in the wall behind, whose type we recognise in an old continental example: there is also a well-designed small octagonal tower and spire at the main intersections of the building; and a turret, also with a stone spire, adjoining the south doorway. The stone is red and white sandstone, with polished red granite columns to nave and chancel, entrance doors, and porches. The whole interior is of white sandstone, with bands, &c. in red. The arches are carried by polished red granite columns. The accommodation is for 200 persons, and the contract accepted amounts (exclusive of granite) to £5350.

Mr. E. M. Barry's name appears only once in the catalogue (137), in a somewhat ineffective view of the costly "Tomb recently erected in Norwood Cemetery." The admixture of materials is more successful than the general idea.

(138) is a little architectural subject, completely exemplified by plans, sections, &c.—a "Boat and Summer House at Isleworth," designed by Mr. Lockyer, who has treated the whole cleverly and artistically. In another part of the room are two other drawings (307, 313) from Mr. Lockyer's careful pencil, giving examples of Mosaic inlays of the twelfth century, from different buildings in Sicily; and (312), showing part of the detail of the "Façade of the Duomo at Orvieto—Italian Gothic, between the dates 1290-1300,—and drawn from actual measurements.

The two vigorous etchings (139) of half-timbered "Cottages

Digitized by Google

erected near Gloucester" by Messrs. Hugall and Male, are, though very small, worthy of examination.

(140), A photograph of a "Design for a Circus," by Mr. Vaughan, jun., to which the Soane medallion has lately been awarded, displays evidence of considerable talent. As engravings of this design have been multiplied in various ways, its leading features are probably too well known to need description. In justice to the author it should be added, that the practical has not been lost sight of in the imaginative, as is too often the case, but that the several plans and sections (which we have had an opportunity of investigating elsewhere) are nothing less than thorough working drawings, and those of a very able description.

(143). "Covent-garden Approaches," Burleigh-street, is one of Mr. Gray's corner blocks of building. Like that in Henrietta-street, it is unfortunately faced with cement, not, we believe, by the architect's preference, but in compliance with the requirements of the surveyor to the Duke of Bedford. In the design before us Mr. Gray does not appear to such advantage as usual, owing to a certain disproportion in some of the parts, and a heavy expression of the entire mass. In (309), where less has been attempted, as also (347), where the work is intrinsically of the plainest possible description, he has been more successful.

We now come to several carefully depicted restorations, by Mr. R. J. Withers (146, 147, 148), being views of the Parish Church of Saling Magna, Essex, of which the chancel, aisle, and vestry were rebuilt, and new fittings added last year, at a cost of £433.

In (154, 155, 156) the same architect exhibits his proposed restoration of the church at Great Amwell, Herts, which has a pretty apsidal chancel dating of the 12th century. Beyond this there is not much to notice. The new fittings are throughout in good taste.

The drawings of the "United Service Club, Pall Mall" (158), showing Nash's original plan, as well as the present one, since the recent alterations by Mr. Decimus Burton, are an acceptable addition to the collection. The improvements, both in point of convenience to the members, and external effect, are such as could only have been attained after considerable study. The extra enrichments which the façades can now boast of, go far to redeem the poverty of the original building, and give it a more worthy rank in the "Street of Palaces."

Mr. Street, in his "Church to be built in Westminster" (160), while manifesting the versatility of his designing powers, preserves the same characteristics of a town-church as were shown in his St. Dionis, Backchurch, engraved in our last December number. There is the same severity of outline, partaking of Italian features (especially in the unbuttressed campanile), and the same judicious blending of the parts by frequent banding of materials; carved ornament is almost wholly wanting, and indeed, would scarcely comport with the general conception of the design.

In (167) Mr. Street exhibits a "Design for a Pulpit," which possesses unquestionable merit, but we confess to having seen others more to our mind. (343) is altogether a wonderful production. It exhibits, on a large scale, an elevation of Giotto's famous Campanile at Florence, drawn from Mr. Street's own sketches and measurements, and displaying the richness of its effect, especially attributable to the profusion of inlay marble work, with which almost the whole surface is covered. Mr. Street has also sent photographs of parts of his "Design for the Foreign Office', (386, 389), and one (9) of his "Design for the War Office."

We are sorry to be unable to compliment Mr. Joseph Clarke on his drawings this year. The interior of Walton Church (170) scarcely deserves the name of a "sketch," nor is "St. Peter's Church, Thanet" (172), satisfactory. St. Luke's Church, Heywood, Manchester (331), about to be rebuilt, is also below the average; but in the Schools at Coggeshall (338), Mr. Clarke has been more successful. The subject is one well studied by him, and in which he has had much practical experience.

Mr. Withers' "Glass-Painting Works and Studio," erecting in Endell-street, Bloomsbury, are chiefly in red brick, characteristically treated, and will form a pleasing feature in a locality which can boast of that excellent specimen of design and execution in brickwork—St. Martin's Schools.

The name of Mr. Digby Wyatt occurs several times as a sole exhibitor, but still more frequently in connection with others, as we shall have occasion to observe by-and-bye. The house, 96, Gracechurch-street, of which a not very flattering view is given in (179), is one of the most noticeable alterations in the neighbourhood. Without adhering to the restrictions of any particular style, the architect has blended a variety of features in a more than ordinarily happy manner. The fact that the general face of the house is set back from that of its neighbours gives no slight help in the matter, serving as much to individualise the design as to admit of a few effective projections. Colour is freely used, as also metal and inlay-work, so that we have here a specimen of each, which is at least suggestive for the future, if no more.

Two other drawings by Mr. Wyatt display (180) a sketch of the "State Bed" designed for the Emperor and Empress of the French on the occasion of their visit to Windsor,—which is, purposely no doubt, French in style, abounding in cyphers and emblematical devices; and (181), two "chimney-pieces" in the Renaissance style—very boldly treated, and slightly aided by colour—for the Right hon. Henry Labouchere, M.P.

The "Station and Hotel proposed to be erected at Birmingham," and designed (in conjunction with Mr. Brunel) for the Great Western Railway (181A), is shown in a very tame pencil elevation. It is of Italian character, and a large mass of building, rather too sparing in ornament considering its locality and object.

We now enter the *East Gallery* which is devoted mainly to competition drawings, hung (for we cannot say quite classified) on a screen in the centre. The first number is (190), Mr. Gompertz's "design for the new College at Rawden, near Bradford," a poor Italian design, shown by a perspective and two plans, the latter not without some good points. At nearly the other end of the screen is (258) another design for the same building, still less satisfactory.

(191, 195, 196) are three competition drawings for the "Wakefield Church Institution," by Mr. Robins, Mr. Mew, and Mr. James. It is of course impossible from such trifling instalments to pronounce as to the comprehensive merits of any design, but as far as external appearance is concerned, we should prefer either the second or third of these to the first mentioned.

The "Hanley Cemetery Chapels" competition is represented by portions of the designs of Mr. Sorby (194, 208), and Mr. E. C. Robins (202). Both are Gothic; the former being of red brick, rather tastefully banded, but overdone in some other respects; while the latter, a very ordinary composition, is so overwhelmed by the fantastical border which surrounds it, that its poverty is rather exposed than cloaked by the contrast, and we notice the same thing in some other drawings. Such very elaborate additions are certainly not in keeping with the subjects they inclose, and are otherwise in questionable taste.

That for the "Worcester Cemetery Chapels" is, by name, represented only in one design, viz., that to which the third premium was awarded, and which is shown by its author, Mr. C. H. Cooke, in a perspective view. The style followed is Norman, but while characteristic massiveness is not wanting in its parts, the massing of the whole appears capable of improvement.

The "Mortuary Chapels, at Brighton," by Mr. R. Wheeler (207), are Gothic, and rather above the average in merit.

We must conclude our notice next month, when we shall also refer to the department of Manufactures, &c.

ON THE USE OF COLOUR IN ARCHITECTURE.*

By SYDNEY SMIRKE, A.R.A.

BEFORE entering upon the subject it will be well to take a short retrospective view of the efforts of architects of past times with reference to the use of colour in their works.

The Egyptian and Assyrian builders seem to have dealt with colours as children in art, and although some have supposed themselves able to discern a superior knowledge and a refined practice of colouring in these earliest and least cultivated ages and races, I confess I can anticipate little benefit from an attempt to inquire into their principles, if indeed any principle they really possessed.

The case however is far otherwise when we descend to the period of Greek art. The learned are much divided in their opinions as to the extent to which Greek architects availed themselves of colour in exterior architecture; and indeed until comparatively late times little regard was paid to the subject. The earlier revivers of Greek art seem scarcely to have heeded it, and the natural effects of neglect, and exposure, more or less, to the action of the atmosphere during 2000 years, have of course been so nearly to obliterate all vestiges of colour, that it is not sur-

* Lecture delivered at the Architectural Exhibition.

Digitized by Google

prising that the earlier observers should have altogether overlooked them. Authorities differ even now so widely as to the extent and character of the colouring practised by the Greeks, and the existing visible traces of colour on ancient remains are so scanty, that he would be a bold theorist who would venture to speak with confidence of the general practice of the Greeks. It is very probable that the different schools of art that prevailed in various districts and at various periods during even the pure Greek era, may have very materially differed from each other in their modes of applying colour. But I shall refrain from detaining you on this vexed question of ancient polychromy. I may remark however that the existing evidences of the use of bright colours in Greek sculpture are such as to preclude all doubt of the practice in that department of art to a certain extent. I would instance the red colour known to have been used to mark the bleeding wounds of Greek warriors in archaic sculpture, and the blackened pupils of their eyes. The fact of bronze bridles and javelin heads occurring in marble sculpture, even of the highest class and of the best period, affords presumptive proof of the use of colour; for detached spots of bronze, unsupported by some accompanying colour, on a pure white marble, are hardly reconcilable with the refinement of Greek art; the lavish use of gold and ivory in Greek sculpture seems also to favour this inference. Indeed those who have paid any attention to this subject will not need to be reminded of the various passages that may be quoted from ancient writers, wherein direct allusion is made to the use of colour by Greek sculptors.

Now, seeing that in the composition of Greek temples the architect and the sculptor worked so strictly together that the two arts were animated as it were by one soul, there seems ample ground for conjecture that the architectural features were treated in the same way as the sculptural portions. In truth, undeniable traces of bright colour have occasionally been detected, and few collections of Greek antiquities are without examples of coloured architectural forms. Thanks to the successful labours of Mr. Charles Newton, architectural painted fragments of the date of Alexander have been brought home and deposited in our national Museum; thus furnishing to us the testimony of all others the most satisfactory,—the testimony of our own senses. This strong colouring over large surfaces in Greek architecture is however by no means proved. At the same time I admit, that much as the pure crystalline translucency of Parian marble would lose by any artificial stain, yet the force of evidence renders it undeniable that at least light, probably transparent, general tints were largely used.

It would be tedious here to enter into a disquisition that has already filled many elaborate volumes. I will confine my present remarks to the testimony of my own experience. The coarse limestone, of which the finest temples of Magna Grecia were for the most part built, appears to have been covered with a thin coat of fine calcareous plaster; this plaster was itself so perfectly white that it is quite impossible to believe it to have been left unstained. It is not to be supposed that the susceptible eye of a Greek artist could have endured in that brilliant atmosphere so painful an object as a chalky, opaque white building. Nor need we wonder that the Greeks should have painted their external architecture. Young Greek art adhered with a sort of filial piety to its early reminiscences, and long continued to regard with deference its prototypes in Egypt and Assyria, where unquestionably the brightest colours were profusely employed. By a somewhat remarkable coincidence the "vermilion beams" of a royal palace are named both in the Iliad and in the book of Jeremiah; and there is indeed abundant evidence to satisfy us that reds, blues, and yellows, in dazzling superabundance characterised the immature art of those early periods.

What the Greeks taught by their example we may safely assume their Roman pupils readily practised. But the Romans introduced a new element of decoration in the profuse use of materials naturally coloured. Bronze and gilt decorations had as we have seen previously enriched the external architecture of Greece; but the Romans, by adding coloured marbles, gave an aspect to their structures to which architecture had previously been a stranger. The use of these marbles, applied both to architecture and sculpture, became a passion in Rome, and the mountains of her remotest colonies were ransacked for the sake of their many coloured contents, and the mechanical dexterity acquired by Roman artists in veneering with these precious materials in the thinnest possible laminæ, seems to have far excelled the workmanship even of the present day.

When the tide of conquest rolled eastward, the use of colour in architecture acquired renewed force. It is worthy of observation that those eastern regions, where all the works of nature seem steeped in the brightest colouring, are peopled by races whose greatest æsthetic characteristic has always been a love of brilliant colouring. Their architecture and their costume alike attests this prevailing taste. Nor was it characteristic of any special race or caste. It was a geographical rather than a national distinction. Whether Jew or Gentile, worshipper of Vishnoo or of Mahomet, all alike delighted, and I may say still to this day delight, in the most brilliant colours, seeking the highest gratification of this sense by reproducing, in the texture of their dresses or on the surface of their edifices, those precious gems which were so strongly associated in their minds with the symbols of rank, wealth, and power. There can be little doubt that it was from these eastern sources, quite as much as from the surviving examples of Roman art, that mediæval builders learnt the value of colour in architectural decoration.

After the first recognition of Christianity by the Roman world it sought to make available, for the purposes of public worship, those existing structures which seemed best adapted to its convenience. The triple stoa basilica of the Athenian Archons had been many centuries before naturalised in Rome and in its Italian colonies; its form and arrangements satisfied the requirements of the Christian communities, and became the model after which their churches were designed during several subsequent centuries. These buildings were erected it is true in a somewhat rude style of art; but their simplicity of form and propriety of decoration well compensated for their want of refinement. Let any one enter one of those early basilicas that has not been mutilated or metamorphosed by later art,—let him mark its simple, unostentatious aspect, the propriety and gravity of sentiment that pervade every part of the design,—and few unprejudiced minds will I think refuse to recognise in them a deeper and more earnest devotion than in that exuberant decoration; the fanciful, artistic *tours de force;* that excessive multiplication of superfluous adjuncts which characterised the later development of ecclesiastical art. Those earlier stones speak of the humility and subjective devotion of an as yet uncorrupted faith. These later stones proclaim the triumph of that secular spirit which, after extorting its treasures from stricken consciences or misguided piety, sought to perpetuate its influence by expending a portion of those treasures on the external pomp of a sensuous ritual and an embroidered architecture.

It is, as I have said, probable that much of this love of rich colouring is due to the infusion of an exotic oriental taste. But as Christianity extended northward, the influence of climate over the predilections of the eye came into operation. Northern mediæval art was nurtured amidst grey mist and under clouded skies, and its features accordingly assumed a graver tone; whilst the exterior architecture of parts of southern Europe, of Byzantium, of Persia, and of India, shone in all the splendour of mosaics and coloured exterior decoration, we find those resources of art but timidly and moderately resorted to in the north of Europe; and this distinction is perceptible even within very narrow geographical limits. In France, for example, whilst in the early mediæval buildings of the more northern provinces few traces of external coloured decoration occur, mosaic and tesselated works are not unfrequently found in those provinces where ancient colonies from the East had imported an exotic taste.

In Germany I am aware of but few indications of such mode of coloured exterior ornamentation; whilst on crossing the Alps we begin to find, at Venice and elsewhere, rich marble incrustations abundantly used, evincing the intimate relations of the Venetian states with Byzantium and the East. In England there is but little evidence of any taste having existed for exterior colour in architecture.

The horizontal courses of variously coloured materials—a mode of striated decoration to which recourse has been had of late in this country—are, it is true, a prevalent feature of the buildings of parts of Italy, and in the East very generally; but, as far as I know, they are a peculiarity foreign to English art, and perhaps I might add to English taste. I must however admit that these observations on the general absence of bright colours in northern architecture require much qualification when we consider the decoration of the interior of buildings. There the love of colour, which more or less characterises the natural taste of all mankind, has I think in all climates, and at almost all periods, been largely indulged. Even in the most unfavourable times artists in mosaic

Digitized by Google

were, as we have seen, found to illuminate, with more or less skill, the walls of ecclesiastical buildings, and their art was among the earliest to participate in the general improvement of architecture.

Perhaps interior coloured ornamentation reached its acme when the Sainte Chapelle, in Paris, and subsequently when our own Saint Stephen's Chapel, were built. But it should be noted that these beautiful examples were preceded by the chapel of Saint Francesco, at Assissi, where an example was set of the most elaborate and brilliant mural illumination,—an example which, by its own intrinsic beauty, as well as by the reputed sanctity of the spot, probably influenced all Christendom. I am aware that the crowning decorations of the Italian example, being by the hand of Giotti, bear a date later than that assigned to the Sainte Chapelle at Paris. But the building was erected long before, and having been executed with incredible rapidity, it may be fairly presumed that the mural decorations were at least far advanced before the Parisian work, by Montereau, was begun. The beautiful building at Assissi may therefore I think be safely said to have led to the splendid rival displays which I have already adverted to in northern Europe.

Abundant further examples might be adduced, illustrating the passion for bright colouring which distinguished the artists of probably the whole period called the Middle ages throughout Europe; and when the style that had prevailed for some centuries began to recede before the revived spirit of Classic art, architectural colourists still retained the practice of their art, although they gave it a new direction. Italy still took the lead. There we find coloured marble incrustations, both external and internal, more prevalent than ever; and panelling in various coloured marbles and jaspers is one of the most strongly marked features of the *quatro-cento* and *cinque-cento* schools. I may mention as striking and well-known examples, portions of the Ducal Palace and adjacent buildings at Venice, the church of Sta. Maria die Miracoli in the same city, and that of Sta. Maria at Florence, with very many other remarkable buildings.

Nor did the use of coloured marbles cease for a long time to be a fruitful source of beauty and variety in the architecture of Europe. It was in the beginning of the sixteenth century that the pleasing style of interior decoration became prevalent, which has been named after the great master whose skilful hand and fascinating example first recommended it. The story told by Vasari of Raphael having derived the idea of his arabesques from the casual discovery of ancient Roman decorative paintings, is familiar to all. We may readily admit the probability of the story, for the subsequent disinterments at Pompeii and Herculaneum, and in the Roman states, abundantly testify to the general practice of ancient Roman art. This epoch is a memorable one in decorative art. It is curious to trace all over Europe, and through three centuries, the permanent wide-spread influence that the school of Raphael has exercised over the whole domain of art.

I have detained you long enough on this preliminary sketch of the history of my subject. It is time that I should proceed to a consideration of the theory of colour, and its application to practice in our art. An inquiry into the theory of colour is attended with this happy peculiarity,—its first principles are simple, certain, well defined, and I may add clearly laid down before us by the hand of nature.

There are but three simple colours. All the researches of science or art we may be well assured will never reveal to us a fourth. It is in the manipulation of these three simple elements that the whole art of the colourist lies, and even in the study of this manipulation there is an absence of any bewildering complexity. As there are but three pure colours, so there can be but two classes of mixed colours,—viz., first, those composed of any two of the pure or primary colours; second, those composed of all the three primary colours. It is obvious that there can be no other compound colours besides those comprised in these two great classes.

The colourist's whole care is therefore limited to the study of three pure colours and two classes of compound colours in their affinities and mutual relations. I must however admit that the straightforward simplicity of our path here ends; for our limits very widely expand when we enter upon an analysis of these compound colours. Their range is in truth infinite; for in the class of secondary compounds there is no limit to the degree of difference in the proportions in which any two primary colours may be blended; so in the class of tertiary compounds there is no limit to the degree of difference in the proportions in which the three primary colours may be blended; no limit, that is to say, except such as is imposed by the limited faculties of the human eye.

When Alison says there is no such quality as inherent beauty in anything, he enounces a very bold, and I may venture to say a very doubtful principle; but there appears to be at least some approach to truth in the dogma when applied to beauty in colour. I will not go so far as to say that there is no inherent beauty in any one colour or hue, although it must be admitted we are greatly influenced by prejudice in our estimation of this kind of beauty. The circumstances of its application materially affect our judgment. Burke cites the colour of a dove as one of its peculiar beauties; but if we argue from thence that therefore dove colour is intrinsically and abstractedly a beautiful hue, we must be prepared to admire it on the female cheek, or the hair, or the lip. I am not however venturing to deny that there may be an inherent property in particular hues to cause us pleasure in the contemplation of them; for philosophers tell us of certain physical effects, vibrations as they are called, on the organs of the eye, produced in various proportions by various colours: but this is a subject far too recondite for our contemplation here, and probably of little practical value; I allude to it only to show that it is not prudent to speak *ex cathedra* on this subject. Still I am sure I may with safety say broadly, that colours are so dependent for their effect on association, that they derive an immeasurable accession or loss of power to produce pleasure according to the art with which they are placed before us with reference to each other. In this respect there is a remarkable analogy between colour and sound. We can hardly say with strict propriety that any one note in music is beautiful; but associate it with others into a chord, according to certain laws of harmony, and the most uneducated ear can at once appreciate the result. This analogy between sound and colour is familiar, and has not escaped the observation of natural philosophers.

It is therefore of the first importance to the student who desires to cultivate decorative art to make himself well acquainted with the principles which should guide his practice in the choice and arrangement of colours; for it is a gross fallacy, and yet a very prevalent one I believe among those who have no practical acquaintance with art, to suppose that pleasing arrangements of colour are fortuitous, or at all events dependent more on what is called fancy than on any definite rule or theory.

It is to these principles therefore that I must now call your attention. I will not suppose that any one here is wholly unacquainted with them; but it will be a wholesome exercise for him to step back, as it were, to those first principles as the starting point from whence to make a surer and more rapid advance.

Let me therefore detain you for a few minutes while I repeat some common truths respecting colour. It is found that when of the three primary colours, red, blue, and yellow, any one of them is placed near to a compound of the other two, a pleasing effect is produced, which is called harmony. To produce fully this effect you will understand that it is necessary that these two colours—viz., the primary, and the compound or secondary—should be seen nearly together or simultaneously, just as when a chord is struck in music. These secondary colours are, in the language of art, said to be complemental to that primary which does not enter into their own composition. Thus green is complemental to red, orange to blue, and so on. Such is perfect harmony in colour.

What is called discord in colours can only be produced, in its strictest sense, by placing in juxtaposition two of the compound colours. Thus a positive purple and a positive orange placed in contact produce a direct discord. But as each of these last named compound colours contain a primary which is common to both—namely, red—the nearer the purple approaches to its component blue, the less directly is it discordant with the orange, and when it has so far advanced as to be capable of being regarded as merely a purplish blue, it has so far attained to the relation of a positive harmony. So on the other hand, as the purple approaches nearer to red its discordance with the orange becomes weaker, until, arriving at merely purplish red, its relations to the orange have so far improved that, although not in strict harmony, it becomes at peace with it. Thus it follows, that whenever a primary colour is used no positive discord can take place, for whichever of the three compound colours be used with it, it must either be in harmony or in peaceful relation with it.

Thus far all is pretty simple and obvious. When however a third colour has to be used, great caution becomes necessary.

Digitized by Google

Should you, for example, have succeeded in bringing a purple and an orange together without offence to the eye, by giving to the orange a yellow tendency, mischief would inevitably ensue from the intrusion of a positive yellow, for you would then, by the contrast, throw the orangish yellow back again in the scale towards the orange, and thus, as it were, renew the feud between the two colours. On the other hand, if in proceeding to interpose upon the purple and orangish yellow a third colour you were to use a red, you would do little or no harm, for this third colour, red, whilst not at variance with the purple, would bring out the yellow tendency of the orange by obscuring as it were the red element of orange, and so far improve its relations with the purple, the direct complemental of yellow. Thus for example, in an apartment wherein the prevailing hues of its furniture and decorations are modifications of a cool purple, orange yellow, and red, the arrangement of colour would be more sure of a favourable result than purple, orange yellow, and blue; for in that latter case the blue would, by contrast, bring out in greater force the orange element, and so aggravate the discord between it and purple. I might of course bring similar illustrations from the combination of the other primary and secondary colours, but enough I apprehend has been said to explain my meaning.

I should remind you that in referring to these secondary colours I have, for simplicity's sake, used the strong definite terms orange, purple, and green, but the same general principles necessarily extend to all those numberless and nameless modifications of hues with which, in decorative painting, we have to deal; the discord or the harmony being however always the more decided the purer and more intense the colours are. Artists however are a peace-loving fraternity, and have contrived a thousand ways of counteracting the conflict of hues. By the mere intermixture of black or white in their pigments, they alone can produce a host of broken tints; slate-colours, buffs, greys, drabs, and many other such, whereby the neutralisation may be carried so far as to produce complete pacification; although of course at the risk of insipidity; of which however there need not necessarily be any danger, for there are many licenses permitted, and constantly practiced by those of highest authority, in order to give animation and variety to the association.

The judicious introduction of a moderate discord will occasionally be not only pardonable, but productive of many happy effects. I believe it to be so in musical composition, but certainly in the matter before us. To know when and to what extent the rigid laws of colour are to be violated with impunity, or indeed with advantage, is a nicety especially deserving your study.

Besides the contrast of hues there are other cognate considerations by no means to be overlooked. A knowledge of the contrast of what is called tone requires your careful cultivation; for variety in the depths of your colours is essential in order to give them all the beauty of which they are susceptible. If all the colours in an apartment are alike strong the effect will be sure to be harsh and violent; if, on the other hand, you keep them all alike faint, the effect will most probably be insipid and washy. In a room so coloured it is surprising indeed how much sparkling animation results from adding even a few lines or touches of strong colour. To borrow a well-known illustration from the experience of our sister art, these touches of strong colour are analogous to the red cloak in a grey landscape. Then there is the contrast of warm and cold hues which particularly demands your study. Red and yellow are the two warm primaries; blue the cold one. Blue, as it advances towards yellow on the one side, or red on the other, loses its cold property in proportion as it loses its own purity. No composition of hues is perfectly satisfactory unless these contrasts of temperature, as one might call them, are duly attended to. If, for example, on a wall or ceiling you have a light warm tint for a panel, and another light warm tint for the margins, to interpose a strong red line would be a mistake, for you would then deprive them of the warmth which characterises them, and perhaps render them both muddy; whereas, let the line be of a decided cool colour, and you at once give all the desired effect to the two adjacent warm tints, however light they may be; thus you gain all your effect with the least amount of colour, and to act otherwise would be a mere vulgar waste of force.

Another remark I would here add whilst on the temperature of tints. When you have both a cool and a warm tint, as for instance in the panelling of a wall, the cooler tint should be the lightest in tone. I speak of large surfaces, not of mere lines or small patches of colour. A strong cold tint as the general wall-colour of an apartment can rarely be made agreeable. The fancies of an unlearned upholsterer are sometimes such as to afford us occasional opportunities of studying every species of obnoxious combination. I have been in rooms wholly clothed in strong blue, and nothing could be more painful than the result. It is true a deep ultramarine over a considerable extent of surface may be seen on the vaulting of both the upper and lower church of St. Francesco, at Assisi; and indeed it appears to have been a favourite colour for the vaulting of churches, where perhaps blue has been adopted as a symbolic colour, or more probably as a representative of the sky, studded sometimes with its stars, rather than on any æsthetic grounds; its effect is often admirable, but this application of deep blue is wholly different from the use of it under ordinary circumstances to which I have been alluding. In the vaulting of a lofty church it is in comparative shadow, and rendered hazy, or neutralised by distance. Besides I can call to mind no instance of this deep blue being used without being considerably broken or relieved by a scattered pattern of stars or other devices of a different colour, often indeed gilt;—in this respect, as well as in many others, following the example set by their Classic predecessors, who usually painted their coffers strong blue, relieved by a painted or gilt ornament.

In considering however the decoration of apartments (the field whereon we are perhaps most frequently called upon to exercise our discretion), it should be remembered that the aspect of the human complexion and the presence of the human figure are not to be wholly lost sight of; and you will find that a large surface of wall strongly coloured materially affects the colour of the light in the room. Thus, red walls impart a warmth to the light, which has usually an agreeable effect on the complexions which receive that light; whereas a large surface of the strong cold colour just referred to chills the light, depriving it of that genial character which is proper to it, besides most seriously damaging all flesh colours within its range.

Whilst on the subject of contrasts, I must briefly advert to the valuable property that colours have of clearing each other. The terms muddy and dirty are very commonly applied to compound hues, which owe their title to those opprobrious terms more to the injurious effects of their neighbours upon them than to any intrinsic defect of their own. Place a clear blue, for example, by the side of some purplish hue, such as dove-colour or slate, and you will deprive it of its blue tendency without in any way increasing the purity of its other component, red, and thus you render the mixture faded and impure; whilst the misapplication of pure red to the same hue would, in a similar way, give to this purplish hue a cold leaden or dirty aspect, by depriving it of its warmth, which, to a certain extent, is essential to preserve the proper character of all tints allied to purple. If, on the contrary, you contrast this dove or slate colour with a buff, or even a simple gold moulding, you will at once clear up this delicate hue, and give it all the value which is due to it. In the same way the clearness or muddiness of the numerous and beautiful class of greenish hues—the tea colours, olives, &c.—depends entirely on the character of the colour with which they may be associated. To put a pure green beside a tea colour would inevitably extinguish the latter, or at all events deprive it of its distinctive character, by obliterating that green tendency which is the true source of its utility, and indeed its peculiar merit.

Now with regard to the combination of colours in unison with each other I have but little to say. It is obvious that it requires no great boldness nor art to bring together various hues of the same colour, nor various tones of the same hue, for *simile simili gaudet*. In bringing together these varieties, each having a close affinity to the other, it is clear you are perfectly safe so long as you take heed that one by its intensity does not annihilate its more modest neighbour.

But besides this association of colours in unison, and besides the harmonious contrasting of colours, about which I have probably said quite enough, there is yet another class of associations —I mean that of a primary colour with a secondary, into the composition of which that primary enters. For example, red with purple or orange; blue with green and purple, and so on. This is an association constantly practised, and quite unobjectionable, so long as care be taken to make the compound hue so decided as to prevent its being turned by the effect of the opposition into an impure primary. Blue and green, for example, are often brought into juxtaposition by the greatest masters of the sixteenth century, as by Raphael and his school. But you will find them kept carefully distinguished from each other by each being made

Digitized by Google

somewhat intense and decided. Take this however as a general rule, that you should never use one hue to deprive another hue of its special character. No doubt in the sister art of painting this rule may have no application; for the painter must often be compelled, by the exigencies of his subject, and much against his will, to introduce an objectionable hue, and he will then neutralise it, or indeed destroy it as best he may. But the room-decorator has no right, for he is under no obligation, to introduce a colour and then to do his best to put it out. When the decorator lays on a tint, either it is the right one or the wrong one. If it is the wrong one, why use it at all? If it is the right one, why neutralise it? I repeat therefore the axiom, never to use one colour in order to deprive another colour of that which is its special character.

The two kinds of association which I have last adverted to,—viz., colours in unison and colours having an affinity to each other, are perhaps the safest to use in the decoration of small apartments. But when the composition spreads itself over a larger surface it is then that we must resort, for variety and effect, to the use of various differing and contrasting colours. If I may venture again to throw light upon the decorator's art by a reference to the work of the painter, we shall find the painters of great historical pieces generally using a force of colour and a boldness of contrast which they would not think of applying to an unpretending landscape or a small cabinet picture of a domestic character. So in our department of art a large hall or apartment of stately proportions demands a force of treatment and a strength of colour which would be wholly inappropriate in the dining-parlour or sitting-room of an ordinary dwelling.

Time will not allow me to dwell much longer on these subjects; but before parting with them it seems necessary that I should touch on what have been termed ternary or tertiary compounds. I allude to the mixed and ambiguous tints produced by the mechanical union of a secondary compound with its complemental colour,—as green neutralised with red; purple neutralised with yellow; and orange with blue, producing hues which have, for the sake of distinction, been called olivine, russet, and citron. I should remind you that in these mixtures the primary can only be introduced as very subordinate in force to the secondary colour, for it is hardly necessary to say that if the primary be made equivalent in force to the two other primaries of which the secondary is compounded, the result would be strictly neutral, or no definable colour at all. These three tertiaries show how important a consideration are these chromatic equivalents or arithmetical proportions of colours. All consist of same colours, but all widely different. As regards these three tertiary hues, although they are in perpetual use, I need say but little of them, for they must be amenable in their application to the same laws that the simpler mixtures are subject to; we have but to keep in mind that, call them by what name you may, they are but neutralised modifications of the three secondary colours, and they are to be dealt with accordingly. These broken hues are often most serviceable, and may be used when pure secondaries might be harsh and violent. I must not here perplex you or myself by entering upon the subject of the exact proportions that these intermixtures require. The discovery of the important principle of chromatic equivalents has led to very remarkable results of great importance to art; but this is a subject fitted rather for the study than the lecture-room.

It now remains for me still to deal with one other cognate matter of essential importance in the compounding and arranging of colours. The two pigments, black and white, hold a very important place on every painter's palette; and although certainly not taking rank among colours (a rank which our most distinguished authority, M. Chevreuil, seems almost unwilling to deny them), yet are they most influential instruments, whether used to qualify other hues, or used in their pure and perfect condition as black and white. It would be an endless task to enter upon an enumeration even of all their effects in combination with other hues, but in their pure state I would wish to impress you with a sense of their high value in architectural decoration. Black, by its perfect opacity and coldness, is of especial use in giving intensity to luminous and warm colours. The buff dress with black border, in the costume of Raphael's well-known portrait, will occur to you at once as an illustration of this. The black pencillings on the blossom of an orange-coloured tulip will also be observed as exercising a similar influence in giving clearness and intensity to the colour.

A black ground gives peculiar brilliancy to almost every colour laid upon it, and by its overpowering depth enables those colours (perhaps I should say requires those colours) to be used in greater intensity than would otherwise be possible without gaudiness. I need do no more than remind you of the beauty of those oriental works where the colours shine out from a black japanned surface. Those medallions, also having a black ground, occurring in the beautiful decorations of Giulio Romano and his school are familiar instances, whilst the black backgrounds to coloured paintings, and other applications of black so prevalent in Pompeian art, give evidence of the early appreciation of black by the accomplished artists of the classic age.

The other pigment, white, on the other hand, by its extremely luminous character, gives depth and value to contiguous hues, however delicate in tone, rendering the faintest tints effective, and redeeming from a faded or washy appearance tints of the most tender and timid character, whilst the brightest colours are found to tell out with augmented brightness upon it.

Before concluding this discourse I may take the liberty of urging on all connected with art the great advantage derivable from an habitual observation of the effects of colour. It is a careful study and a constant habit of observation that will alone secure to us a practical knowledge of the principles of chromatic art, and a well founded confidence in their application. Not only should attention be constantly alive to the effects of colour in its actual application to architecture, but the architect would do well to be habitually observant of colour in pictures, endeavour to enter into the mind of the painter; ascertain his motives, and study the treatment of his colours; for be assured every able painter has as good a reason for every variety of hue that he presents to your eye, as the mechanician has for every screw and lever that he works into his engine.

THE SOCIETY OF BRITISH ARTISTS

Has opened its thirty-sixth annual exhibition in Suffolk-street, Pall Mall, with upwards of 800 pictures, which are seen to advantage under the altered light of the rooms, although perhaps it is now too much subdued. Contrasted with other galleries the difference is very perceptible. The pictures which by right claim the first attention are those by Mr. Hurlstone, the president. Several by Mr. J. B. Pyne, are important acquisitions, and convey a wonderful idea of perspective effect, combined with highly finished and harmonious colouring. Although from their peculiarity of handling they are not likely to be overlooked, we cannot forbear pointing out (64) "The Street of the Tombs, near Rome;" (167) a view of "Genoa," eminently Turneresque in its treatment; and (389) "Boppart, on the Rhine." Mr. E. J. Cobbett's name occurs both early and often in the list. (11) "Heather Belles" is a delightful picture, on which a deservedly high price is fixed. (188), "Children Nut Gathering" is another work of like merit, as is also (515), "A study in Brittany." Mr. Boddington introduces us as usual to some of his favourite atmospheric effects. In (19) the misty vapour of early morning is excellently given. "Tintern Abbey," seen by evening light (187), furnishes a truthful contrast. "The Haunt of the Moor Hen" (458) introduces us to a different scene, very cleverly depicted; and the first snow in "Autumn" (497), shows that fidelity to nature which invariably distinguishes this artist's pictures.

Another number that we have marked is (173), entitled, "The Opinion of the Press," in which Mr. Roberts too faithfully expresses the disappointment of an artist at the non-success of his cherished hopes, owing to adverse criticism on his picture in the public journals. Mr. Vicat Cole sends some very good works—(34), "Spring Time," is one of these, and (174), "The Road over the Heath," another. (350) is one of the most extraordinary pictures in the room; the subject is "Beech Trees," whose foliage and the leafage on the ground are rendered with the utmost artistic skill and Pre-Raphaelite minuteness. (459) is another "peep" in the same locality, viz., Albury, Surrey, a spot well known to artists. We may, in passing, compare these pictures with (387), Mr. Whaite's "Woods above Clovelly," which shows a different mode of treatment, but not less truthful. Several other pretty landscape scenes may be singled out; for instance, Mr. E. Boddington's "Summer Evening" (71); Mr. Danby's "Tynemouth" (232); Mr. Wainewright's "River Scenes" (256 and 281); also the same gentleman's picture called "Grazing on the Mountains" (617);—"Wood-cutting, Rivington, Lancashire" (460),

Digitized by Google

by Mr. T. C. Johnson; "a Grassy Bank" (652), by Mr. R. Collinson; Mr. A. Penley's "Windermere" (728).

Mr. Dobbin has two excellent Spanish views: one of Salamanca, (674), showing the church with its domed tower, and the other (822) is a general view of the city of Segovia;—and Mr. Shayer, a capital "Beach Scene" (77). Among the floral beauties must be mentioned Mrs. Rimer's "Camelias" (79).

The only picture exhibited by Mr. F. Leighton (213) evidences considerable study, but will not increase the expectations created by his productions in former years. He has chosen a difficult subject—"Samson and Delila,"—and treated it in a bold manner. Mr. Woolmer is, as usual, in full force.

A clever little work, emanating from Messrs. Herring and Rolfe (217), is called "Dangerous Play," and shows three horses in vigorous action. It is also a very good bit of colouring. The "Aguador's Stall at Seville" (245), by Mr. Villamil, is exceedingly well painted; so also are Mr. Dobbin's "Alhambra" (798), and his "Burgos" (779). Mr. Shayer's "Dairy Cottage" (282), with its neighbour (283) "Under the hedge" (J. Rees), also deserve mention. The grandeur of Norwegian scenery has given Mr. West ample scope for producing effective pictures in Nos. 348, 456, and 528.

There are a few contributions of the Pre-Raphaelite stamp, such as Mr. Rossiter's "Fair Musician" (502); Mr. C. J. Lewis's "Home, sweet Home" (598); Mr. Tucker's "Blackberries and Wild Flowers" (638); and Mr. Smallfield's "Late Supper—full with horrors" (727).

Scanty indeed is our architectural list,—more so by far than usual. Mr. A. Allom's views in Bruges (313) and Ghent (570); also Mr. Wood's "Market-place, Rouen" (607), and "Tower of the old Abbey of St. Bertin, St. Omer" (385); with Mr. L. Lewis's "Place St. Croix, Tours" (794). A view of Algiers (242) gives a glimpse of its architecture; and the temple at Philæ will be recognised in Mr. Mawley's view of the island (820). Mr. Luker exhibits three continental views: (330) "Rue St. Catherine, Quimper;" "a Public Well in Brittany" (334); and an "Auberge" (346), also in Brittany. (437), "A Street scene, Sandwich," is cleverly sketched. (575), "Dolbadern Tower, Carnarvonshire," the citadel of the Castle, and a circular building, erected probably as early as the sixth century, is shown by Mr. Swarbreck in (575); and the "Tomb of Henry IV., Canterbury Cathedral," is beautifully drawn by Mr. Nash, jun. (694): the canopy is of wood, and there is some excellent mediæval ironwork.

GREETLAND CHURCH, NEAR HALIFAX.

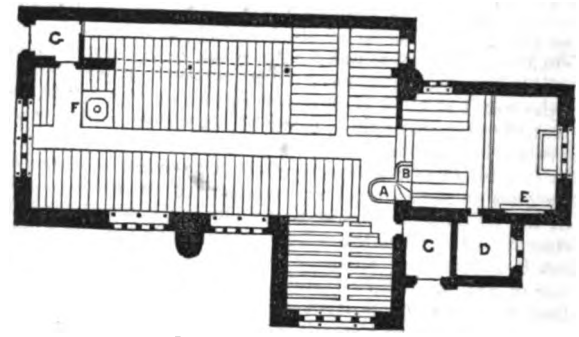
(With an Engraving.)

This Church is now in course of erection at Greetland, near Halifax, Yorkshire, and when completed will present marked points of difference to any of the churches of the locality. The material employed is entirely the stone of the neighbourhood, known as Greetland-stone, which is used for the interior as well as the exterior of the building. There is not any plaster on the interior walls.

The ground plan consists of nave, chancel, south transept, and north aisle, the latter being separated from the nave by three bays. At the west end of the aisle is a porch, under the same roof as the nave. The sacristy juts out on the south side of the chancel, and between it and the transept is a porch, consisting of an entrance door surmounted by a circular window with plain cross tracery. The chancel arch is a circular one, of bold sweep and excellent proportions, each bracket from which it springs is supported by two elegant polished marble shafts with carved capitals. Each of the three arches in the nave differs from the other, the one nearest the east end being especially to be admired for its noble proportions and elegant span. The roof is an open timbered one, that in the chancel being treated in a different manner to the nave, and the wall plate is elaborated by carving.

The west window is of four lights, as is also that in the transept. In the south wall are two windows of four lights each. The east window is a triplet one. All the tracery work partakes of the Geometric in the earliest style of its development. Every window is deeply splayed, and, both externally and internally, all are enriched with slender shafts either of polished marble or slate, with carved capitals. The bell turret springs from the east gable of the nave. The length of the church is 67 feet, the chancel being 27 feet. The altar is raised upon steps, and the pulpit and reading desk, which are of stone, are grouped together at the south angle of the chancel wall. The font is placed near the west porch; and the stalls for the choir are in the chancel.

The estimate cost is £2300; the number of sittings 500; the fittings are of stained deal. The whole is from the designs of Mr. Thos. H. Rushforth, architect, London.



References to Ground Plan.

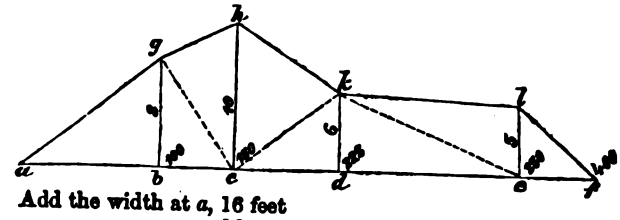
A. Pulpit.
B. Desk.
C. South porch.
D. Vestry.
E. Sedilia.
F. Font.
G. West porch.

SIMPLE METHOD OF CALCULATING EARTHWORK.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Can you or any of your readers tell me whether the following method has been previously applied to the calculation of earthwork?

Let *aghklf* be a section of a cutting, the formation width of which is to be 16 feet, and the slopes 1½ to 1.



Add the width at *a*, 16 feet
" " *c*, 16 "
" " *g*, 40 "

$\frac{1}{3})72 = 24 \times 150 \times \frac{8}{2} = 14400$

This gives *agc*; then take the widths at *g*, *h*, and *a*.

At *g* 40, at *h* 46, at *c* 16 $= \frac{102}{3} = 34 \times 50 \times \frac{10}{2} = 8500$

Then at *h* 46, at *c* 16, at *k* 34 $= \frac{96}{3} = 32 \times 75 \times \frac{10}{2} = 12000$

Then at *c* 16, at *k* 34, at *e* 16 $= \frac{66}{3} = 22 \times 200 \times \frac{6}{2} = 13200$

Then at *k* 34, at *l* 31, at *c* 16 $= \frac{81}{3} = 27 \times 125 \times \frac{5}{2} = 8437$

And lastly at *e* 16, at *l* 31, at *f* 16 $= \frac{63}{3} = 21 \times 50 \times \frac{5}{2} = 2625$

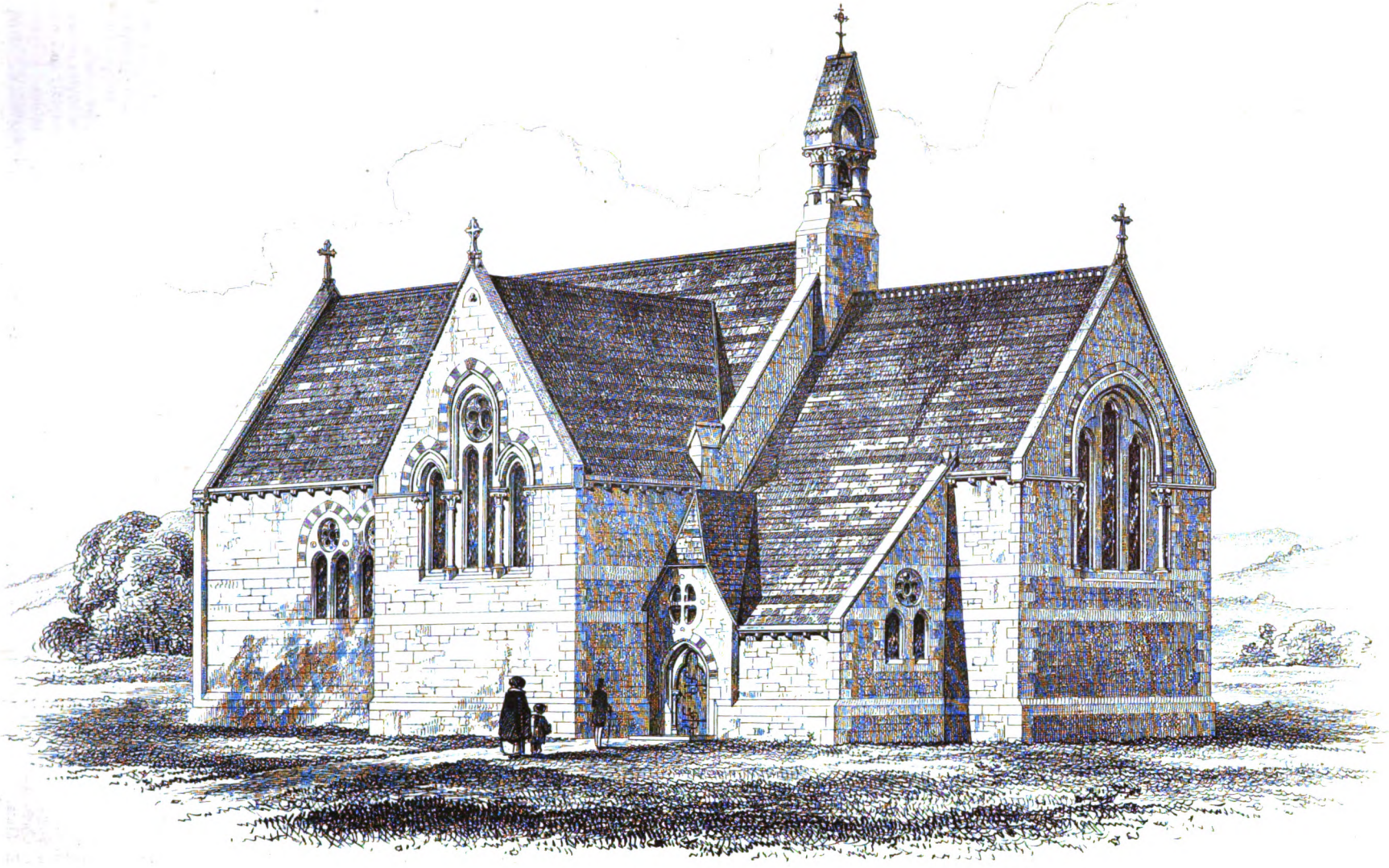
27)59162 feet

2191 yds.

which is precisely the same result as that given by Sir John Macneil's tables, or any others calculated by the prismoidal formula. It will be seen that the method is simply to take the widths at the three points of the triangular piece to be calculated. At the base these are determined by the width of formation; at the surface, by the ratio of the slope. One third of these multiplied by the length and half the height, gives the cubic contents in feet. Unless where one has tables calculated to a given formation, earthwork may be as rapidly and accurately calculated by this method as by ordinary tables. If it is a new method, it may be mentioned that its discovery is due to Mr. Alex. Johnston, assistant engineer, Scottish Central Railway.

A. S. W.

Digitized by Google



May 1859

J.R Johnins.

GREETLAND CHURCH, YORKSHIRE.

T. H RUSHFORTH, ARCHT

Digitized by Google

Digitized by Google

TELEGRAPHIC ELECTRICITY.*

On the Practical Bearing of the Theory of Electricity in Submarine Telegraphy, the Electrical Difficulties in Long Circuits, and the Conditions Requisite in a Cable to Insure Rapid and Certain Communication.

By S. Alfred Varley, A.Inst.C.E.

In the year 1838, Dr. Faraday clearly developed the principles of induction and conduction, since which time no further progress has been made in the fundamental truths of the science, though much has been done to confirm their correctness and to develop their consequences. In the 'Philosophical Transactions' for 1838 will be found Dr. Faraday's views on the subject of induction and conduction.

To determine for myself the law which induction obeys, in conjunction with my brother Mr. C. John Varley, I have tried some experiments.

The principle upon which these were based was that of the dual character of electricity, and the fact established by Dr. Faraday, that all statical charge is sustained solely and entirely by induction.

In bodies in their normal condition the opposite forces or electricities being balanced and united, no attraction for neighbouring particles exists, but when these forces are separated, as in the case of a Leyden jar, the attraction which a given quantity of electricity exerts for the similar amount of negative on the opposite coating, will be less in proportion to some law as the thickness of the dielectric intervening is increased.

It was therefore assumed that the amount of free attraction under these circumstances, or more correctly the amount of induction which would be thrown upon neighbouring bodies, would increase inversely as the attraction between the opposite coatings diminished.

The apparatus made use of was constituted in the following way:—A glass pillar, varnished for better insulation, was mounted upon a board. On the top of this a brass plate was attached, and upon this plate the dielectric to be examined was laid. Over the dielectric another brass plate was then placed. A Leyden arrangement was thus constructed, the upper and lower brass plates representing the inner and outer coatings of an ordinary Leyden jar. A brass ball, suspended from a balance, which had an adjusting arrangement, so that it could be raised or lowered, hung over the upper metal plate at a short distance from it.

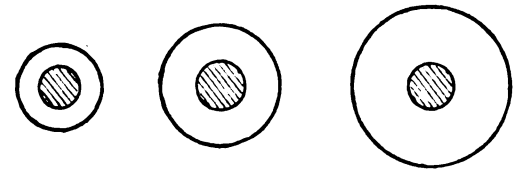
The *modus operandi* was as follows:—The upper brass plate was connected to the earth, and a series of sparks, through the medium of a sliding rod kept at a fixed distance from the prime conductors of a friction machine, thrown into the lower brass plate of the Leyden arrangements, or the prime conductor was kept fully charged, and a carrier ball attached to a long glass rod was made use of to measure out definite quantities of electricty. The room in which the experiments were performed was heated with a stove, and the dryness of the atmosphere indicated by a hygrometer, so that the insulation might be as perfect as possible. When a certain number of sparks had been thrown into the lower brass plate, the upper brass plate was disconnected from the earth, and the lower one attached to the balance, and if the tension of the charge was sufficient the brass ball suspended from the balance was attracted down, and discharge ensued. The experiment was repeated again and again, and the number of sparks requisite to just attract the ball down noted. Glass plates were the dielectric employed, and the experiment was tried first with one plate, then with two, and then with three plates of glass between the upper and lower brass plates, the brass ball suspended from the balance being kept always at a certain fixed distance from the upper brass plate.

The results obtained from a numerous series of experiments were,—that when two plates of glass were placed between the brass plates, only half the number of sparks which were required to raise the tension of charge sufficiently to cause discharge when one plate of glass separated the glass plates was requisite; and when three plates of glass divided the upper and lower brass plates, then a third of the number of sparks raised the charge to the same degree of tension; showing that through flat plates of glass induction decreases in the inverse proportion to the thickness of the dielectric,—that is to say, if the induction through one be 12, through two it will be 6, through three 4, and so on.

In the case of a gutta-percha covered wire it was anticipated that as when the thickness of the gutta percha is increased the outer surface increases at the same time, the decrease of induction consequent on the increased thickness of the insulating material would not be inversely proportionate to the depths of the gutta-percha, but would follow some other law.

To put this to the test a series of Leyden arrangements were constructed in the following way:—three pieces of tube, of half an inch internal diameter and 2 ft. 6 in. long, were placed in the centre of tubes of 2 feet long, the internal diameters of which were 1 inch, 1½ inch, and 2 inches, and the space between the inner and outer tubes filled with melted resin (figs. 1, 2, 3).

Fig. 1. Fig. 2. Fig. 3.



By this means three Leyden arrangements, with a uniform internal surface, but whose insulating material varied in thickness in the proportion of 1, 2, and 3, were constructed, and the same process as that already described with the flat plates was repeated. The results obtained are shown in the annexed table:

Diameter of inner Tube.	Thickness of Insulation.	Diameter of outer Tube.	Inductive Force.
10	5	20	22
10	10	30	15·5
10	15	40	11·5

These results were very constant, but as resin was the only dielectric employed, the experiment requires repeating with other dielectrics, for there is reason to believe that with glass at least the decrease in induction consequent on an increased thickness of the dielectric would be somewhat greater than that indicated in the above table.

The reasons for this belief are the following:—When a galvanic battery is connected with the inner and outer coatings of a Leyden arrangement, induction will take place through the dielectric, and if the surfaces of the two coatings are equal, then the force will be equally divided over them; that is to say, if the battery force be 100, the tension of the charge on the one coating will be 50, and that on the other will be 50 also, =100.

Let the surface of the outer coating be supposed to be infinite in extent, then the tension of the charge on the inner coating will approach infinitely near to 100, and the tension of the charge on the outer coating will be almost nil. An example of this we have when the earth represents one of the coatings of a Leyden arrangement; and this is the case in the prime conductor of a frictional machine, and also in the suspended wire of a telegraphic circuit; in these two examples the prime conductor of the machine and the wire of the telegraphic circuit represent the one coating, the air the delectric, and the earth the other coating.

Now consider a case where the outer surface is double that of the inner one, the tension of the charge on the inner coating will then be double that of the outer; an example of this we have in the above table, where the inner surface is 10, the thickness of the insulation 5, which may here be regarded as unity, and the outer surface 20,—the battery force being 100. Divide this into three parts, and we get 33⅓. Give two parts for the tension of the charge on the inner coating, and one part for the tension of the charge on the outer coating, then we shall have for the tension of the inner surface 66⅔, for the outer surface 33⅓=100 when united.

Now consider the third example in the above table. Inner surface 10, thickness of insulation 15, outer surface 40, or quadruple that of the inner surface. In this case the tension of charge on the inner surface will be four times that of the charge on the outer surface. In other words, the tension of the charge on the smaller surface will be 80, and that of the outer surface 20, the united tensions equalling 100; but the thickness of the insulation is 15, or three times that of the first example; and it has been shown that induction decreases in the inverse proportion to the thickness of the insulating material; we shall therefore have to divide by 3, and this will give 26·3 for the tension of the charge on the inner surface.

* Abridged from a Paper read before the Society of Arts.

Digitized by Google

In the first example it has been shown that if the force be 100 the tension of the charge on the inner surface will be 66⅔, which to avoid fractions we may regard as 67. In the actual experiment the inductive force measured was 22; 67 therefore represents 22, and as 67 is to 22 so should 26·6 be to the amount of force which would be expected to be obtained in the last example; this, when calculated by a simple rule-of-three sum, gives 8·8 for the amount of inductive force. In the actual experiment the force obtained was 11·5, a result therefore sufficiently near to warrant further investigation, to ascertain whether the law which would seem to be indicated is correct, and whether it holds good with any other dielectric, such as glass, in which case the cause of the discrepancy when resin is the dielectric employed, should be sought after.

I now proceed to conduction.

The law which governs the conduction of electricity has been very accurately ascertained, and would seem to follow the same law as induction; that is to say, if the sectional area be uniform throughout, the resistance which a conductor will oppose to the passage of a current will be directly relative to its length; or the length of the conductor being determined the resistance will be relative to its sectional area. In other words, a wire one mile long will oppose half the resistance of that which will be opposed by a similar wire two miles long; and two wires, each two miles long, placed side by side, which is the same thing as one of twice the sectional area, will oppose exactly the same resistance as a single wire one mile long.

The next thing to be considered is the part which the quantity and intensity of electric currents play in electric phenomena.

The amount of force developed by an electric current, whether it be the deflection of a needle, the attraction of an armature in an electro-magnet, or the decomposition of water, is always relative to the dynamic quantity flowing.

This fact has been well established, and the difference between quantity and intensity accurately defined; yet still in practice there is a want of a clear comprehension of the relationship of those terms.

Let a battery—say of ten pairs of elements, with 10 inches of surface in each cell—be joined through a circuit perfectly insulated, and opposing very great resistance to the passage of the current; and the amount of force, or in other words the dynamic quantity of electricity flowing, be weighed off by a magnetometer and noted down. If now this battery be disconnected, and another of the same number of elements, but with twice the surface, be connected in its place, practically no more will be found to be flowing through the circuit than in the former case, the resistance which the wire opposes measuring out the quantity passing somewhat in the same way as the height of the column, and not the quantity of water in a cistern, regulates the rate at which it flows from an orifice inserted in it.

Let the series be increased, and more will be urged through; and if the number of cells be sufficiently numerous for practical purposes, the same dynamic quantity as a single cell would generate through a circuit of no resistance would be found to be flowing.

In theory this point can only be approached, for the resistance of the wire can never be completely overcome. In theory also, when the number of elements is not increased, the larger the surface the greater will be the dynamic quantity flowing, for the tension of the current is lower in proportion to the amount of electricity flowing out of the battery; and when drawing from a larger reservoir, which batteries of greater surface may be compared to, this same amount will not lower so much the general tension; consequently there will be more intensity to urge the current through. But to return to practice. If the number of cells has been sufficiently extended so as to generate the same dynamic quantity as a single cell does through a circuit of nominally no resistance, a further addition to the series will not be attended with any beneficial effect, for there is already power enough to urge through all the electricity the battery is capable of generating; and the force developed is directly relative to the dynamic quantity flowing. Tension is only the medium by means of which this dynamic quantity is forced through the circuit.

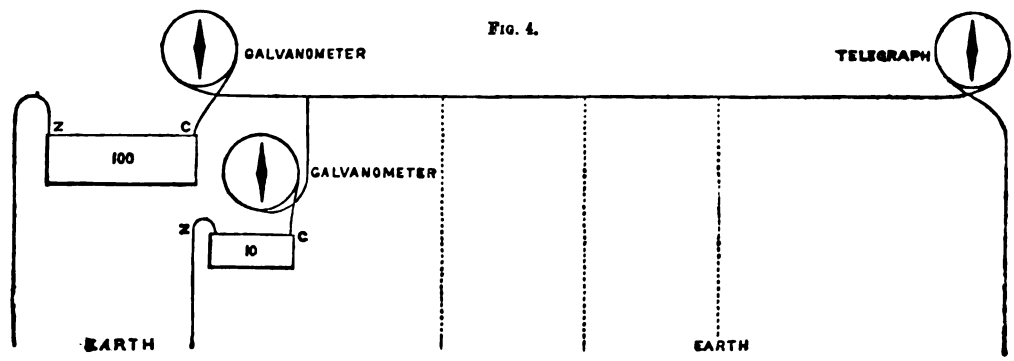
It will be as well perhaps to define more precisely what is wished to be understood by the term resistance. When it is said that one circuit opposes twice the resistance of another, it is meant that the same tension of current will force half the dynamic quantity only through this circuit that it would through one opposing half the resistance; it follows that a given length of wire opposes the same resistance to half the dynamic quantity of electricity that half its length of wire does to double the dynamic quantity, and hence all circuits oppose to an infinitely small quantity of electricity an infinitely small amount of resistance.

The way in which quantity and intensity affect practical telegraphing has next to be considered, and whether there be any advantage in employing comparatively large over smaller dynamic quantities of electricity.

It may be generally stated that when the insulation is very perfect there is no great difficulty in working with minimum quantities; but when the insulation is imperfect larger dynamic quantities hold out a better prospect of working through.

When a current is flowing through a circuit which offers, practically speaking, no resistance, let the cells of the battery be ever so numerous, it will possess no intensity worth noticing; for as there is no resistance opposed to the force resident in the battery, the intensity is not brought into play. It is something like a powerful engine raising a light weight, the force is latent, but not brought into action. Let the battery however be connected through a circuit opposing considerable resistance; its intensity will then be developed.

Fig. 4.



Let the diagram (fig. 4) represent a circuit which fulfils these conditions, one end of the wire dipping into the earth in the usual way, and the other connected with the copper pole of a battery composed of a numerous series of elements possessing very little surface, and consequently capable of generating only a small dynamic quantity of electricity; and let the circuit be completed by connecting the zinc pole to the earth.

The current will flow from the copper pole through the wire, thence to the earth, and back to the battery, and its working intensity will be dependent on the resistance which the circuit opposes, and can be measured in the following manner:—Let another battery, but with a much smaller number of elements, be connected side by side with the larger battery to this wire, the zinc pole being connected to the earth and the copper to the wire, and introduce galvanometers in the circuit, between the large battery and the wire and between the small battery and the wire, so as to indicate the direction in which the currents are flowing.

Both batteries will desire to send a current through the circuit in the same way, but should the small battery oppose much less resistance to the passage of a current through itself than is opposed by the long wire, then the greater quantity of electricity generated by the large battery will pass that way in preference to through the wire, and paralyse the action of the smaller battery; but if cell after cell be added to this little battery, when its in-

Digitized by Google

tensity becomes greater than the resistance of the wire, a current will flow from it also in the same direction as that from the large battery through the wire, and the number of cells requisite just to do this will be an exact measure of the working intensity of the current.

Let the case now be considered where the insulation is not perfect; if there be sufficient leakage to let the small dynamic quantity which the battery can only generate escape on the road, no appreciable amount will reach the further end, the tension of the current will be lowered, and a less number of cells in the little battery will now be found to balance it.

Adding to the number of these small pairs of elements will not give any appreciable assistance, but let the surface in each of the cells of the larger battery be increased so that a greater quantity may be generated than can escape through the leaks, represented in the diagram by the dotted lines, an appreciable amount will then reach the further extremity, and the telegraph instrument be rendered active. In such a case as this, adding quantity will raise the working intensity of the current, whilst increasing the intensity of the battery alone will scarcely affect it.

Previous to the first attempt to submerge the Atlantic cable, a series of experiments were undertaken by the company's late electrician, and the result published.* These experiments having been tried at the expense of much capital, and with opportunities which never before presented themselves, are too important not to be noticed, though it is believed that the author of them has lately had reasons to modify some of his conclusions. The chief results published were these:

1. That no adequate result is obtained by increasing the sectional area of the conductor; that, in fact, in the case of a submarine circuit a small wire will transmit signals more rapidly than a larger one.

2. That an insulated submarine wire conducts according to a different law to that of a suspended circuit.

3. That the rate at which a voltaic signal travels is not affected by the intensity of the battery.

4. That magneto-electric induced currents have the property of travelling in the first place faster than voltaic ones; and unlike voltaic currents, when their intensity is increased their rapidity of travelling is increased also.

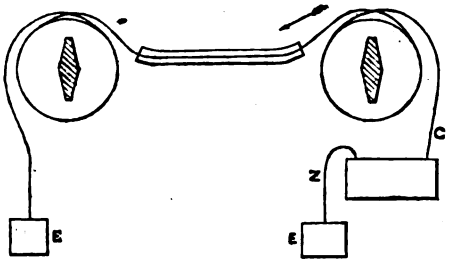
In the paper I submitted to the Institution of Civil Engineers† I pointed out what I conceive to be errors in these results, and endeavoured to show that some of them necessarily followed from the way in which the experiments were conducted. Before proceeding further, and to prevent the possibility of mistake, it is desirable to make the following quotation from the work previously referred to:—‡

"The law of squares may possibly apply to the transmission of electricity freely along simple conducting wires, but it certainly does not apply to the case of its transmission along submarine and subterranean gutta-percha covered wires (the facility of transmission being estimated by rate of speed), because in this the case is not one of simple conduction, but of transmission, after the wire has been charged inductively to saturation as a Leyden jar."

This quotation shows clearly the reason for concluding that small wires are better conductors for submarine circuits, as far as transmission is concerned, than larger ones; for the smaller the Leyden jar the more quickly will it be charged to saturation. The author, in differing from these conclusions, does not wish it to be understood that he thinks the law of squares is applicable to submarine wires; for he is not aware of any electrical phenomena which obey that law; but he submits that there is a material difference between a Leyden jar and a submarine wire.

In a Leyden jar the inner and outer coatings are perfectly insulated one from the other. If they were not insulated there could be no statical charge, as is well understood by all electricians. Induction therefore involves insulation. But in a submarine circuit this is not the case. If the wire at the further extremity were disconnected from the telegraph instrument and sealed up with gutta-percha, the conditions would be nearly the same. In practice however it is quite open through the instrument to the earth, and the resistance opposed by the very long length of wire is the only insulation between the inner and outer coatings, for it unites both, being in connection with the earth at both ends (fig. 5). It is therefore evident that if the wire offers no resistance there will be no insulation, and as a consequence no induction to retard the passage of the current. It is also equally plain that precisely in proportion to the resistance which

Fig. 5.



the wire opposes, provided always the insulating medium be of the same thickness, will induction manifest itself and retardation be experienced.

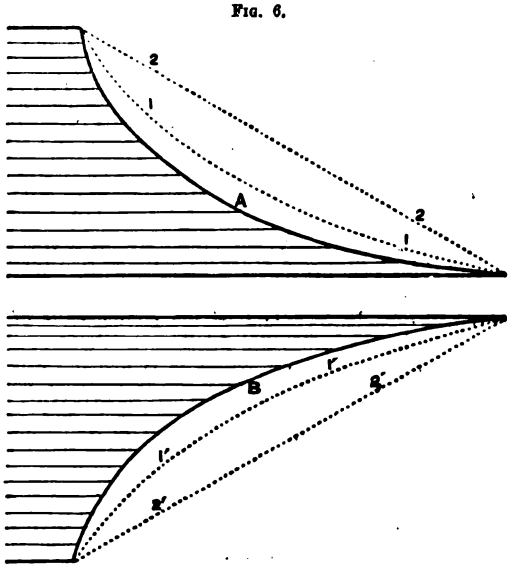
There is also another difference between a Leyden jar and a submarine circuit. The Leyden jar is charged uniformly all over, whilst in a submarine wire the tension of the charge varies in different portions of the circuit, being at its maximum at the end where contact is made with the battery, and dying off to nothing at the further extremity.

The next consideration is the part induction plays in submarine circuits of any considerable length.

In a submarine circuit the wire is insulated from the earth by only a thin layer of gutta-percha; the conditions therefore are favourable for induction through the insulating material; the conductor itself from its great length opposes very great resistance, or in other words, insulates to a very great extent.

When a battery is connected to send a current, the first impetus is in part directed forward, in part diverted laterally; but as the wire opposes considerable resistance to the passage of the electricity which the battery can generate, whilst the thinness of the insulating material is very favourable for induction taking place through it, the greater portion of the first rush will be occupied in charging the wire statically at the battery end; as however it is a balance of forces between the resistance which the wire opposes on the one hand, and the ease with which lateral induction can take place on the other, a very minute portion must pass through instantly, and the period which will elapse between the making contact with the battery and the observing the current at the

Fig. 6.



further extremity, will depend upon the capability of the instrument to record very small quantities of electricity.

In fact, immediately on contact being made with the battery a wave will be formed throughout the length of the wire, somewhat like what is shown in the diagram (fig. 6), which is intended to represent a submarine wire the moment after contact has been made with the battery. The line A represents the internal charge having its maximum tension at the battery end, and diminishing

* *Vide* 'The Atlantic Telegraph. A History of Preliminary Experimental Proceedings, &c., published by order of the directors of the company.'

† See *C. E. & A. Journal*, vol. xxi. p. 167.

‡ 'The Atlantic Telegraph,' page 28.

Digitized by Google

in intensity as it approaches the farther extremity. The line B shows the induced charge of the opposite kind on the outer surface of the gutta-percha, and forms an exact counterpart to the internal charge, with the exception of being a little less intense; for as it is spread over a greater surface, and only exactly balances the internal wave, its tension will be less in proportion as its surface is greater. As the tension of the statical charge is raised so will the flow of electricity at the further extremity increase; both will arrive at their maximum together: the current will then flow in a regular stream as long as contact with the battery continues. The dotted lines 1 1 and 1′ 1′ are intended to represent the waves after contact has been made a short time, and the lines 2 2 and 2′ 2′ are intended to represent the waves when they have attained their maximum height. In the last case they will be perceived to be more regular.

When the battery has been disconnected from the wire the opposite waves will still continue to unite, but the rate of flow as the tension falls will become slower and slower.

In theory the time which would be occupied by a wire discharging itself completely in this way would be infinite. In practice the wire requires a very appreciable time to charge, and a longer period to discharge. The effect of this is, that if currents are sent at all rapidly one after the other, instead of obtaining a series of distinct impulses at the further extremity, an undulating continuous current is received; and, as to obtain a telegraphic signal the wire has not only to be charged to a certain degree of tension before an appreciable current is received at the further end, but has also to be discharged afterwards before another signal can be sent, the impulses which are obtained through such circuits as these are very sluggish.

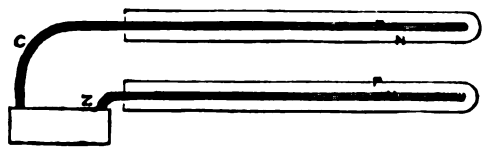
The problem to be solved is the best means of reducing the amount of induction, and of mitigating its effects.

Almost the first remedy suggested when this inconvenience was experienced, was to substitute another insulated wire in the place of the earth for a return circuit; for it was argued, that as in this arrangement one wire would be charged positively and the other negatively, they would neutralise one another. This suggestion was put to the test and failed. Since that time the same plan has been revived by several others; a good deal of argument has also been brought forward lately in support of it, and even amongst those who know its practical inutility there would still seem to have been lurking some faith in the capability of the method—in theory at least—to neutralise the effects of induction.

The explanation of its failure, if we are guided by the first principles of the science, appears to me to be very simple, and I expect not only to make it plain that no advantage is to be obtained by the adoption of this method, but that it will increase the retardation.

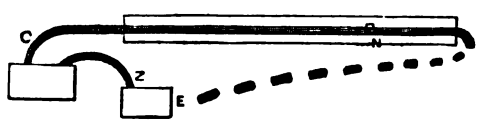
Let two long gutta-percha covered wires (fig. 7), buried in the earth, be connected, one with the zinc pole and the other with

Fig. 7.



the copper pole of a battery, and let the farther ends of each of these wires be hermetically sealed. The earth from its mass being a perfect conductor, its action it is evident will be the same as if metal tubes in metallic communication with each other surrounded the gutta-percha wires. It is therefore clear that the only retardation to induction will be the thickness of the gutta-percha covering, and the tension of the statical charge will be in accordance with the intensity of the battery. Now consider the case of a similar gutta-percha wire of the same length (fig. 8) as one of these, but in which one pole of the battery is

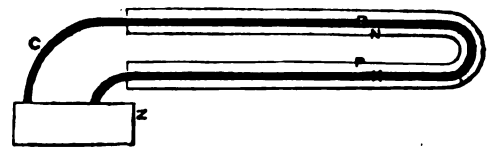
Fig. 8.



connected to the earth and the other to one end of the metallic conductor, and the circuit completed by connecting the further extremity to the earth. It will also receive a statical charge to a certain degree, but the tension of the charge will not, *cæteris paribus*, be dependent upon the intensity of the battery, but upon the resistance which the wire opposes, for it has already been shown that this is the only real insulation between the wire and outer coatings, and that the degree to which statical charge can take place depends on the amount of insulation existing.

Now let the ends of the two wires which are hermetically sealed be connected to each other (fig. 9); the circumstances are

Fig. 9.



quite as favourable for induction as in the wire in which one end was connected with the earth, but there will be twice the resistance; in other words, double the amount of insulation, and consequently a proportionate increase in the amount of induction.

Another view of this matter will perhaps assist to confirm what has just been stated.

It is a well established fact that when a telegraphic circuit is composed of a loop of wire, it will oppose the same resistance as a circuit of double the length where the earth is made use of in the place of a return wire, and this proves that the earth offers no appreciable resistance. If this be the case, what difference can it make whether the battery pole be carried to the end of the wire itself, or through the medium of any length of a perfect conductor, which the earth has been proved to be. Therefore it would appear that the induction which would be manifested in a circuit composed entirely of an insulated conductor, would be the same as that in a circuit of twice the length where one half the circuit is completed by the earth; and the only difference which would exist between the one and the other would be, that in a circuit composed entirely of wire the statical charge will be distributed more uniformly throughout the entire length.

Fig. 10.

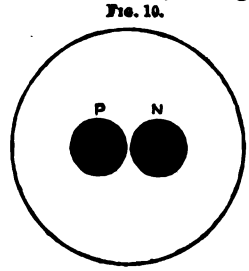
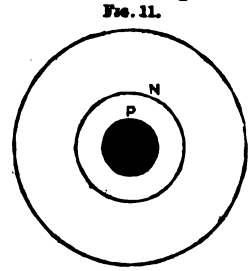


Fig. 11.



"But," says a writer on this subject, "I admit that no advantage would result if two separate wires are used, and which will therefore necessarily be some distance apart from one another, but place the two wires in the middle of a mass of gutta-percha (fig. 10), and so close to each other that they may become virtually the centre of a system, and let the insulating material be of considerable sectional area, then no induction worth naming will take place between the wires and the earth, and the inductive influence of the positive wire will neutralise that of the negative wire."

The fallacy of the proposition will be at once seen if it be carried out more fully. Instead of letting the wires lie side by side, let the one wrap over the other, and be in fact a tube with a thin mass of insulating material between it and the inner wire (fig. 11). They will now become really the centre of the system, and fulfil completely the object desired by the author of this suggestion; but is it not evident that such an arrangement is the fac-simile of a Leyden jar, and will not the conditions be the most favourable that can be conceived for the development of induction?

The only remedy which has been successful in mitigating the effects of induction, is that of throwing into the wire, immediately after a current has been sent, another of the opposite kind: this absorbs and neutralises the preceding wave much more quickly than when the wire is left to discharge itself in the ordinary way. This method however does not reduce the induction, but only mitigates its effects; although in circuits of moderate length its adoption has for practical purposes completely removed the inconveniences arising from the induced charge.

There are only two ways of reducing induction, the one is to

Digitized by Google

increase the thickness of the insulating material, and so render the conditions less favourable for its development, and thus approach the conditions of a suspended circuit, where the induction having to take place through a considerable space of air—a dielectric of very low specific inductive capacity—there is but little accumulation of statical charge, and consequently the impetus is almost entirely directed forward, and scarcely diverted laterally to any appreciable extent.

In gutta-percha covered wires, when the insulating material is increased in size, it has been shown that the full effect of the increased thickness is not obtained, owing to the outer surface increasing at the same time.

There is also another quality possessed by resinous substances, and probably by gutta-percha, worthy of consideration. It is the property of absorbing a charge in the mass of the substance, instead of its being confined entirely to the surface; the tendency of this will be to still further reduce the advantage of an increased thickness of insulating material.

A reference to first principles will make this clearer. All bodies insulate to a certain extent, and the only difference between a so-called conductor and insulator that would appear to exist is a difference of degree; and if a charged body is brought into the neighbourhood of an insulated conductor induction will take place through it in the same way as through a dielectric; but owing to the particles of conducting substances possessing the property of readily communicating their forces one to another, the inductive force developed at the further extremity will, within certain limits, be scarcely affected by the length of the conductor through which induction is taking place. The absorption of a charge within the substance of the dielectric is an approach to this condition, but its practical moment when gutta-percha is the insulating substance has to be determined by experiment.

Lessening the induction by reducing the resistance has next to be considered.

The first thing obviously will be to obtain a metal of the highest specific conducting power, for could the sectional area be diminished without increasing the resistance, the induction would be reduced proportionately to the decrease in the surface. The next will be to increase the sectional area of the conductor, and although this involves increased surface, yet there will be a gain; for when the diameter of a wire is enlarged the surface over which the amount of induction extends does not increase in the same ratio as the sectional area which determines the resistance opposed by a conductor. To make this clearer, let four cables ranged side by side be employed as one conductor.

Such an arrangement will possess four times the sectional area and oppose only one-fourth the resistance; in other words, the same tension of current will force through four times the dynamic quantity of electricity that would be generated through the single cable when used alone. Signals would not however be transmitted more rapidly through the four cables than through the one; for although the conducting power has been increased, four times the surface has been quadrupled also, which will just counterbalance the lessened resistance: but merge the four into one, the external inductive surface will then be halved, whilst the sectional area will remain the same as before, and there will be only half the induction manifested.

It therefore follows when a wire is enlarged, that as the sectional area increases as the square whilst the surface increases only in regular proportionals, the relative balance of forces in favour of rapidity of conduction will in a submarine conductor of a given size be twice the amount of that in a wire of half the diameter.

I would now attempt an explanation of how it happened that an actual retardation was observed in some of the experiments with the Atlantic cable when a conductor of enlarged sectional area was employed; and on this head I would again quote from my remarks on a former occasion:—

"In the experiments to ascertain whether any advantage would result from the use of an increased sectional area of metallic conductor, recourse was had to joining the cables side by side, the increased inductive surface which such an arrangement involved having possibly been overlooked. This will account not only for an increased speed not having been obtained, but for an actual retardation having been noticed. Electro-magnetic induction coils do not create electricity, they simply offer a ready means of converting electricity of low tension and considerable dynamic quantity into electricity of very high tension and small dynamic quantity. The quantity evolved by them is always smaller in proportion as the intensity is greater. Both cannot readily be obtained together, and if a very high intensity is required, the quantity must be sacrificed unless the size of the apparatus is immensely increased. This difficulty has evidently been appreciated, as the induction coils used by the Atlantic Telegraph Company are of large size and great length, so as to obtain high tension with an appreciable dynamic quantity. Nevertheless, there is little doubt but that the quantity evolved even by these machines, when compared with that generated from voltaic batteries, is small. This being the case, on giving the current a larger number of channels to rush into, there is not enough electricity to fill the wires, consequently the tension of the current will be very much lowered. The effect of this will be that a longer time will elapse before the tension of the wire will be raised sufficiently high at the further extremity to render itself apparent on the instrument. To obtain under such conditions the same speed with four cables as would be obtained with one alone, it would be necessary to employ four of these induction coils ranged side by side, and worked with four times the battery surface, so as to generate four times the dynamic quantity of electricity. When qualified with these conditions, under which no doubt the experiments were tried, the reasoning contained in the Atlantic Telegraph Company's pamphlet, given in an earlier portion of this paper, is correct. It is precisely a case of having four Leyden arrangements to charge instead of one. A telegraph cable is in fact a Leyden arrangement, which has to be charged to a certain degree of saturation before signals are obtained. The degree to which it has to be charged statically depends upon the extent of inductive surface compared to the conductibility of the metallic core. In a circuit where the conductibility of the metallic core is very great, compared with the inductive surface of the insulating material, no high degree of statical charge can take place, and signals will pass quickly. The opposite effect will be noticed in a circuit where the inductive surface is very large compared with the conductibility of the metallic core. The wire will then have to be statically charged very highly before a perceptible current will flow from the further extremity, and signals will be obtained proportionately more slowly."*

The reason why signals are found to pass when magneto-electric induced currents are employed in place of voltaic ones arises, I believe, not from any specific difference between them, but simply from the tension of the induced currents being very much greater than any voltaic ones which have been employed.

On this head I will say nothing further here, but would refer those who may take an interest in it to my paper of a former occasion, where I have fully entered into this subject, and also attempted an explanation of how it has happened that in the experiments with voltaic currents of varying intensities, no difference of speed has as yet been observed.

The amount of retardation which will be experienced in submarine circuits possessing conductors of varying resistance, and insulated with different thicknesses of insulating material, it appears to me can, comparative speaking, be readily determined by actual experiment.

I have for a long time been engaged in designing an apparatus for this purpose, and at the time I arranged to give this paper I fully expected to have had the apparatus completed by this time, and to have been able to have laid it before you on this occasion; and though I regret not being able to do this, yet I feel I have sufficiently advanced to warrant my explaining the principles of its construction.

The principles upon which it is based are: that a body which offers the same resistance as another without reference to its substance or length may, as far as conducting power is concerned, be considered electrically the same. If we make use of a substance or metal of any inferior specific conducting capacity to that of the metal employed in submarine circuits, and also of greatly diminished sectional area, the same resistance as that offered by the very longest circuits can be obtained in a very small compass; and such an arrangement will, as far as simple conducting power is concerned, fairly represent a long submarine circuit.

The induction which manifests itself in submarine circuits can also be obtained if the conditions for its development are as favourable as they are in submarine conductors.

The apparatus consists, 1st, of a series of resistances, the values of which are known; 2nd, of a series of induction plates,

* *Vide* 'The Atlantic Telegraph.'

Digitized by Google

the values of which when compared with a given surface of a gutta-percha coated wire are also known; 3rd, a mechanical arrangement to accurately measure minute periods of time.

By a combination of the resistances and the induction plates, a conductor, which will fairly represent a submarine circuit, will be obtained.

The resistance can be diminished or increased, and the inductive surface can be doubled or halved at pleasure, and thus circuits with conductors of varying lengths and sectional area, and different thicknesses of insulating material be imitated, and the law which governs the retardation in the transmission of telegraphic signals determined by direct experiment.

It may be argued that as the inductive surface in a telegraphic circuit is uniformly spread throughout a series of induction plates will not present the same conditions, but it is evident that they may be divided throughout also, and although they will not then precisely represent what is actually the case, the result will approximate very closely to those obtained from a submarine conductor.

Perhaps it would have been prudent not to have called attention to an apparatus before its completion. I have done so however because I have felt it was due from me to endeavour at least to point out how some of the important problems involved in submarine telegraphic communications between distant stations may be resolved.

The chief deductions from what has been brought forward in this paper are:—1st. That the metallic core of a submarine cable should be composed of a conductor of the highest specific conducting capacity. 2nd. That a decrease in the retardation which is caused by the induction that takes place in submarine circuits can only be obtained by increasing the thickness of the insulating material, but that it will be better to do this by enlarging the sectional area of the conductor as much as is practicable.

In designing a cable there are many considerations besides those of its simple electrical qualifications which have to be entertained. The object to be obtained is the best result with the most economical investment of money. Are the proportions which were adopted in the Atlantic cable the best to ensure this?

The weight of the conducting coil in this cable is about 63 lb. to the mile, the value of which, speaking roughly, would I suppose be about as many shillings. When served with gutta-percha the value was raised to £40 per mile. The iron sheathing and getting the cable on board brought its value up to £100 per mile. The expenditure however did not cease here; there was the hire of ships, salaries of staff, &c. In this cable therefore only four per cent. at the outside was invested in the conductor upon which the transmission of the messages depended.

If the views which I have brought forward are correct, a conductor of double the diameter would only produce half the amount of retarding force of one of half the size. Such a conductor at the very outside would not cost more than £16 per mile, and the increased expenditure in serving such a conductor with gutta-percha, and giving it an iron sheathing, would not, comparatively speaking, be very large; the expenses of the staff and the hire of the ships would be about the same in both cases; the latter would be perhaps increased slightly, but not to any material amount.

There are a great many other points which should be entertained in such a paper as this, but the paper has already run out to such a length that I will not trespass any further on your patience: and in conclusion I would only add, that if the ventilation of the subject, through the medium of this communication, should tend in any way to the progress of electric telegraphy, the object of its author will have been obtained.

Discussion.

Mr. C. V. Walker had attended to listen and learn, rather than obtrude his own views upon the meeting; but being called upon, he would offer a few observations. The difference which Mr. Varley remarked between the Leyden jar and a submarine cable, was that which was generally recognised; it was simply a difference of degree as to the relative states of the inner and outer coating. The cable did practically possess all the distinctive character of the Leyden jar, notwithstanding that the inner and outer coatings were connected, as the experiments made with the Atlantic cable illustrated. The experiments worked out in the early part of the paper to determine the law of induction, would be found very clearly laid down by Sir William Snow Harris, in the little book published by Weale. He had shown that the law of induction was inversely as the distance, and directly as the surface. The next clause of the paper referred to "intensity." This term had led to much confusion; moreover, he thought in the present state of electrical science the conditions regarding conduction were far more completely expressed by the formula of Professor Ohm, than by Mr. Varley's diagrams. Another question in connection with submarine cables was the size of the conducting wires. This was a very important one, and he was quite sure they would think he was possessed of very little modesty if he ventured to give judgment upon a matter which, in his opinion, was so entirely a question of experiment that he only wondered the great cable was laid down before this important point had been satisfactorily investigated, so as to put the matter beyond the possibility of question, whether that conducting strand of seven wires was too large or too small. An opportunity occurred to him to try some experiments with seven or eight distinct miles of insulated wires, of different sizes and different thicknesses of gutta-percha insulation. The wires were in lengths of about one mile each, and the results of those experiments were decidedly in favour of a small wire as the conducting medium. There were many points in connection with small wires worthy of consideration, one of which was cheapness, because although the percentage of saving upon a mile of wire was small, yet the saving would be very great in a cable to extend across the Atlantic. The smaller the wire was the greater the insulating power obtained from the same amount of gutta-percha. The alleged advantage of the smaller wire was, that there was a greater resistance in the circuit; but in the pamphlet published by the Atlantic Telegraph Company, the experiments made by Mr. Reid were described, from which it appeared that he sent a signal through 1000 miles of cable with a battery of two plates only, excited by his tongue, so that the resistance to be overcome by that small battery could not have been great. Another point was the return wire, and upon that he considered the whole question of the Atlantic cable turned. What helped them on the one hand hindered them on the other. The effects of the magnetic disturbances of the earth would be obviated by a return wire. If two lines of cable were laid down, and the current passed to Newfoundland by one wire and returned by the other, this inconvenience would be got rid of, but they would have the other inconveniences which Mr. Varley had laid before them. If the two wires formed portions of the same cable they would cause a greater amount of retardation, because one wire would polarise the other. But if two wires were used in the same cable in a somewhat different fashion, namely, if one was laid as the centre wire, and the other carried spirally round it, and the current divided between the two wires, the polarisation would be very much reduced, if not entirely annihilated. Those two wires, however, would act externally upon the outer coating, which would render the advantage nugatory. In his opinion the next Atlantic cable would not be coated with an iron jacket, as the former one had been; but a coating of hemp and other non-conducting materials would be employed. It might be interesting to the meeting to know the time it actually took to send signals through the Atlantic cable. By Whitehouse's induction coil it took 1¾ seconds, whilst the battery current was 6 seconds in its passage through, at least as far as he recollected.

Professor Tyndall would ask, had any particular experiments been made to ascertain the law of, or the benefit to be derived from, thickening the wire? Had experiments been made to determine the law by which retardation was diminished, when the thickness of the gutta-percha coating was increased?

Mr. Cromwell Varley said he could answer some of the questions put by Professor Tyndall. He had consistently recommended to the Electric and International Telegraph Company the use of wires of large diameter, for the last twelve years, as the only means of obviating the difficulties experienced on long circuits in wet weather from leakage, which, with the earlier forms of insulator used, was very great. Since the introduction of submerged wires he had pointed out the advantage that would be gained in such circuits of great length by the use of copper wire of large sectional area. On his recommendation the directors of the above-named company had tried both of these experiments on a large scale. They had erected iron wires of No. 3 wire guage on the London and North-Western Railway, on the Great Western, and the London and North-Western Railways, instead of the usual size (No. 8). The results were such that he had no doubt they would never again, for long circuits (viz., of over 200 miles

Digitized by Google

in length), erect other than thick wires. They had tried thick wire under the sea in their new cable connecting England with Holland. This cable contained four conductors of No. 13 instead of No. 16 wire, and although, for reasons explained further on, the relative speed of this compared with that of the former size was not so great, yet there was a very decided gain in rapidity, together with much stronger and much more uniform and reliable currents. These wires were connected both in England and Holland with a considerable length of overground wire, which latter was much affected by changes of the weather, and the gain in unfavourable weather from using the larger wire was, as predicted, very considerable. He was very much surprised to find Mr. C. V. Walker adhering to, and supporting, views which other well-known electricians had put forward, viz., that increasing the sectional area of the wire did not increase the rapidity of the transmission of electric signals. The experiment, however, had been lately tried in the new Dutch cable, and although the relative speed was not exactly known, because there were many difficulties in the way, yet the fact was established that increasing the sectional area had greatly increased the speed. He had tried to determine the effects of induction, &c. on the speed of the electric wave; not only had the inductive effect to be taken into consideration, but also the absorption of electricity by the surfaces of the dielectric; and these influences were ever changing by heat and by the charging of the wire, to such an extent that approximate results only were obtainable, which, however, were sufficiently near for all practical purposes. The absorption of electricity by the surface of the dielectric required time, and therefore cables of such length and dimensions as would only work slowly suffered more from this absorption than shorter and quicker ones. The retardation of the wave in a cable was caused by the lateral induction absorbing part of the electricity intended to give the signal through the line, and until this charge approached the maximum the current at the distant end would be weak. If two cables were made, the one with an iron and the other with a copper conducting wire inside the gutta-percha, all other things remaining the same, the former would have as much induction as the latter, because this had reference only to the surfaces of the dielectric. As the iron wire would only conduct at one quarter the speed of the copper, it would require, with a given electromotive force, four times as long to transmit a given current. The electricity would require, in the case of the iron wire cable, four times as long to charge the gutta-percha by lateral induction as the copper wire would, consequently such a cable would have only one quarter the speed of the other. Were it possible to compress twice as much copper into the same diameter, and so double the conducting power without increasing the inductive surfaces, the speed would be immediately doubled. This was not possible, and the effect could only be obtained by increasing the sectional area of the wire: increasing this four times, doubled the interior surface of the gutta-percha, which was the chief inductive surface, and, leaving out of consideration for a moment the exterior surface, the conducting power would be quadrupled while the induction was only doubled; hence there would be a gain in speed of from 1 to 2. But there was more still than this gained; first, suppose the diameter of the small wire to be unity, and the thickness of the gutta-percha covering also unity, the exterior surface of the gutta-percha would be 3, and the combined surfaces of the gutta-percha would be $3 + 1 = 4$. In the second case, where the copper wire was doubled in diameter, and quadrupled in weight, there would be two for the inner surface of the gutta-percha, and four only for the outer surface, instead of six,—collectively, six instead of eight. Hence, doubling the diameter more than doubled the speed. The third gain from the large wire was, that, having a higher speed, there was less time for the absorption of electricity, and, consequently, the disturbance and retardation from this cause were less. Having a current of four times the power entering the cable, and the leakage being less in proportion to it, the current received at the distant end would be more than four times as powerful, and much more regular; the apparatus would be less frequently interrupted for adjustment, and would, consequently, work without intermission for a much longer period than the smaller wire. Mr. Walker had alluded to the Atlantic cable, and stated, in proof of the sufficiency of the diameter of the copper wire, the fact that a single element of water battery gave a current perceptible at the other end. He (Mr. Varley) contended that this proved nothing as to its ability to transmit intelligible signals. In an Atlantic cable we must have not only a wire capable of giving currents and signals, but of giving such currents and signals as should overcome the friction and inertia of the apparatus used for indicating them; these currents must be so powerful and constant, that, when the philosopher had left the cable to the ordinary manipulator, the currents should not fluctuate so much as to interrupt the intelligibility of the communications. The current must have such force, that the varying friction of the apparatus should not materially influence the recording of signals. In the Atlantic experiment these difficulties were overcome to a great extent by a most ingenious little instrument,—Professor Thompson's reflecting galvanometer. In this instrument the only friction was that of a single thread from a silk cocoon, supporting a very short magnetic needle only $\frac{1}{4}$ of an inch in length, which carried a small mirror made so light as to weigh only a grain or two. The mirror reflected back through a lens a ray of light, and thus, without impeding its free action or adding to its friction, a long but imponderable arm was added to the needle to magnify its motion. This little needle was rendered more or less nearly astatic, by placing a large magnet under it to neutralise the earth's magnetism; and thus a nearly astatic instrument, sufficiently rapid in action from its small dimensions, sufficiently sensitive by its long imponderable arm (or ray of light), sufficiently free from friction by being suspended from a filament of silk, was obtained, and by it the faint signals through the cable were rendered visible. These signals were watched by a clerk, and recorded by hand on a Bain's printing machine. He (Mr. Cromwell Varley) felt that sufficient credit had not been given to Professor Thompson for this instrument, without which the Atlantic cable would never have transmitted a single message, and the world would not have had this great experiment to guide them, as there would have been no means of ascertaining whether the cable had reached the bottom of the Atlantic without parting. Such an instrument, however, was not calculated to meet the requirements of a commercial undertaking, because the reflected spot of light was difficult to follow with the eye for any length of time, and was often recorded by the manipulator incorrectly. The current must have sufficient force to record itself. With regard to the insulating properties of gutta-percha: when pure and free from moisture he had found it to rank amongst the best dielectrics, but this was not the condition of the gutta-percha used on cables, which appeared to be porous and to contain moisture. When the gutta-percha was sufficiently heated to free it from this, there was great danger of altering its character, and rendering it liable to become brittle and to crack. In the Atlantic cable, even before it had been put under water, the loss of current by leakage was so considerable that less than one-third of the original current only reached the distant end. Were the loss constant in quantity it would not so much matter, but wherever the current escaped through moisture, there was polarisation and ever-varying resistance at the leaky spot. As an example, he would quote one of many similar cases that had come under his notice. In one of the London and Liverpool wires, there was a defect in the Kilsby tunnel, caused by a filament of wood in the gutta-percha, which was wet at this spot. This leak gradually got worse and worse, and sometimes offered a resistance equal to ten miles of the line composing the circuit, and at other times, especially after the continuous passage of a positive current for some length of time, it offered a resistance equal to more than a thousand miles of the circuit. The fault was situated nearly half way, roughly speaking, 100 miles from the end, and when it offered a resistance of only 10 miles, $\frac{1}{11}$ only of the current from London reached Liverpool, assuming the rest of the line perfectly insulated. When the fault from polarisation, &c. offered 1000 miles resistance, the current which reached Liverpool was $\frac{1}{101}$ of that which left London; these fluctuations sometimes took place in a second of time. The formula for such a case was $e = \frac{El}{1+y}$, where e was the current received at the distant end, E the current leaving the original station (London), l the resistance of the leak, and y the resistance of the line between the leak and the receiving station. Now in the former case the current was amply powerful enough to work the instruments, and no inconvenience would have been experienced had the fault remained constant; but on the contrary, it was always varying in force, and to such an extent that it was impossible to work the line, though only 200 miles in length. Thus it would be seen that, leaving out of the question induction, and its consequent diminution of speed, a conductor of sufficient size must be had to cause these leaks to bear only a small proportion to the current transmitted, in order that the

Digitized by Google

received signals might be sufficiently regular and equal in force to record themselves with certainty and ease. Unless these conditions were attended to, the cable as a commercial undertaking would inevitably fail. With regard to the rapidity of conduction of the electric current, his opinion was that the current began to flow from the distant end *immediately* after the near end was connected to the battery. Electricity showed no signs of compressibility or elasticity, and was without inertia. Suppose for a moment that a cable was divided into several portions, each of which was without appreciable resistance, but separated from the next portion by a given resistance,—the first portion, on coming in contact with the battery would be instantly charged, and as instantly would begin charging the next portion, but to a lower degree than itself; this second portion as instantly charged the third portion, to of course a still lower degree; and this the next, and so on to the end. By careful reasoning on the known laws of electricity, he had come to the conclusion that the current began to flow out of the distant end instantly, but so feebly at first that the most delicate instruments failed to show it. Before concluding he would draw attention to the unhappily chosen terms "quantity" and "intensity." What in England was generally understood by quantity, was in Germany termed intensity, or I. What in England was termed intensity, or tension, was the electro-motive force; in other words the $I = \frac{E}{R}$, where I represents the power of the current to decompose a given quantity of an electrolyte, E the electro-motive force of the current, and R the resistance of the circuit. These terms had unfortunately led many into error, more especially the word intensity.

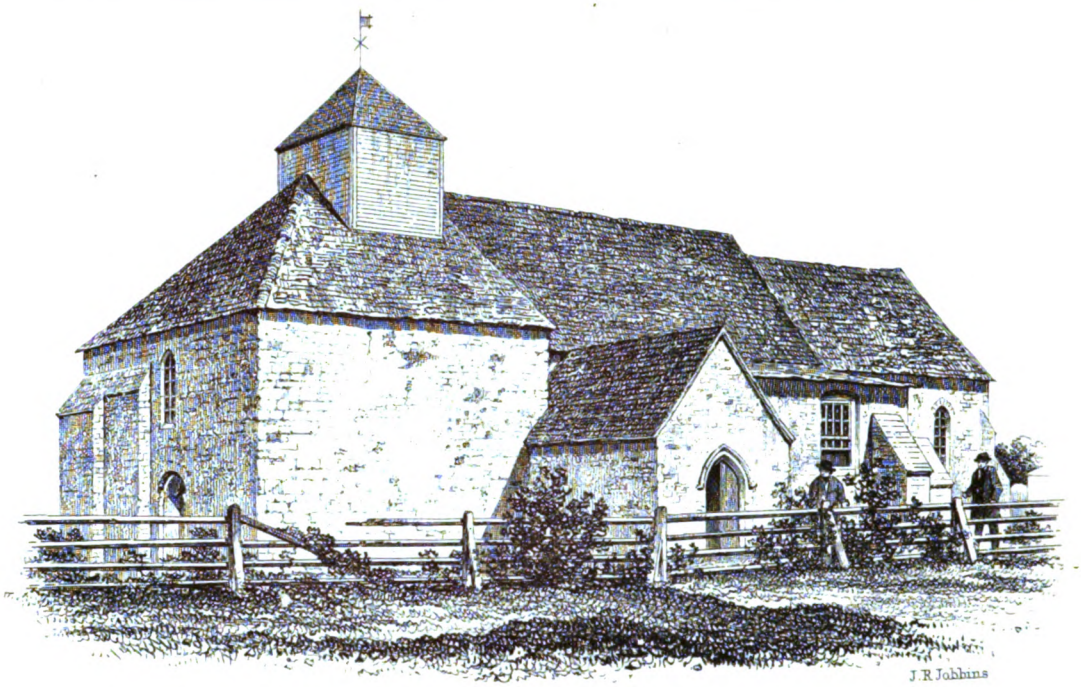
Mr. C. W. Siemens agreed with much that had been said in the paper. He was decidedly in favour of a large conductor of the very best specific conducting power; and had maintained from the first that the conductor of the Atlantic cable was totally inadequate. When he read a paper last year before this society, he had expressed the laws by which the proportion of an electric cable should be regulated for a given length by a simple formula; and he thought that a mathematical expression properly explained was preferable to an explanation in words only, even for a popular assembly like the present, because it combined all the elements to be taken into consideration. He did not agree with Mr. Varley that an electric wave, on entering a submerged conductor at one end, presented itself in however slight a degree instantaneously at the other. The laws of induction and conduction, as he understood them, were directly opposed to such an assumption; and in his own experience he had certainly never observed any indication of it. The line expressing the relative amount of charge at different points of the electric wave in the conductor was expressed not by a dynamical curve, as Mr. Varley had shown it, but by a straight line, terminating abruptly upon the horizontal line which represented the conductor. Another portion of the paper dealt with the complete metallic circuit in submarine conductors, which it was generally understood had been first proposed by his (Mr. Siemens') brother. Mr. Siemens could not agree with the views expressed by Mr. Varley, and by several others who had lately written in the scientific journals upon this subject. Some of them seemed to lose sight entirely of the most essential condition, namely, that the two conductors were to be imbedded in the same insulating medium. His brother had never for a moment assumed, as seemed to be supposed, that lateral induction between the two conductors constituting the circuit would be obviated. On the contrary, it would be rather increased, on account of the greater resistance of the metallic circuit. But it was maintained that the charge between the conductors and the larger surface of the sheathing would be nearly entirely obviated; that the working of one metallic circuit in a multiple cable (which his brother had chiefly in view) would not disturb the electrical equilibrium of the other conductors; that the losses by leakage would be reduced, enabling him also to reduce the area of the conductor, and thereby also the lateral induction between them; that the metallic circuit was not affected by magnetic storms; and finally that considerable advantage could be obtained by the mutual acceleration of the positive and negative currents by Volta induction. So long as a single conductor could satisfy the public demand for messages, the advantages of a metallic return wire would probably not warrant the additional expense, but wherever several conductors became necessary the advantage of working through metallic circuits would be very great. Mr. Varley's illustration of surrounding the one conductor by the other in the form of a tube did not meet the case, because the tubular conductor possessed the very condition which it was intended to avoid, namely, an extended inductive surface both against the inner conductor and the outer sheathing. Mr. Siemens had only one other point to remark upon, and that was of an historical nature. Mr. Varley had stated that Mr. W. Siemens had first employed gutta-percha coated wire in Prussia in 1850, where he had observed the phenomena of induction also. It was however in 1847 when the first gutta-percha coated line wire was laid down successfully near Berlin; and he (Mr. Siemens) exhibited specimens of it, and explained the phenomena of charge which had been observed, before this society in 1848. He might also observe that the statements which had been circulated, that the gutta-percha coated wire as first prepared in Prussia had proved an entire failure, were very unfair towards his brother. These wires had been coated in the same manner as they were at the present day, although it must be admitted that the quality of the gutta-percha employed was very inferior. These lines had however done good service for four or five years, when they began to fail; some of them had however lasted much longer, and some—covered with lead—were actually in use to the present day. He did not think that a much more favourable result had since been obtained elsewhere.

Mr. Leonard Wray said he would make but a few brief remarks upon some of the points under discussion. The best diameter for the conductors of electric telegraph cables was so very much discussed, and so very much disputed, that he would only present to the notice of the society one very singular and significant fact bearing upon the question. When telegraph wires were first introduced into India, Sir W. O'Shaughnessy and his staff were sadly annoyed by the continual breaking of their wires, caused by the very large birds alighting upon them. To remedy this nuisance, that gentleman employed very thick, strong wires, which the birds could not injure; and this great increase in the size of the wires brought out the remarkable fact that no insulation whatever was necessary at the posts, around which they were simply wound. This deserved, he thought, to be recorded in such a discussion as the present. Another subject to which he would refer was that of insulation. Now the substance almost universally employed as an insulating material was gutta-percha; but they were told, and many of them knew it as a fact, that gutta-percha absorbed no inconsiderable quantity of electricity,—indeed, that it became to a certain extent saturated with it. Such being the case, it must be evident that gutta-percha was by no means a perfect insulator; for he held it as an axiom, that no really good and perfect insulator would absorb electricity. The greater the quantity of electricity absorbed by the insulating material used, the greater would be the retardation of the current. Hitherto then a substance had been employed which was very far from perfect, and all calculations had been based upon its known insulating properties; but if they had a superior—a very much more perfect insulating material,—would it not be possible to construct cables with a far less quantity of that material than gutta-percha? He thought so, and he moreover believed that such an insulating material as he had spoken of would probably be soon discovered.

Mr. S. A. Varley said he had but little to reply to, as no attempt had been made to refute the views he had brought forward. He was unable to follow Mr. C. V. Walker throughout, and he did not clearly see the direction in which his views tended. Mr. Walker appeared to object to the statement made, that there was a difference between an ordinary Leyden jar and a submarine circuit; yet he admitted that the conductor united the inner and outer coatings of a submarine wire when regarded as a Leyden arrangement, and that the resistance it opposed was the only thing which prevented the free flow from one to the other. Now he (Mr. Varley) thought this was a most important admission, for upon it depended the reason why a large wire conducted more rapidly than a smaller one, and this was no longer a theory, but an ascertained fact. If there were no difference between a submarine wire and an ordinary Leyden jar, and if a submarine circuit had to be charged statically to saturation before signals passed, as was stated to be the case by the advocates of the small wire system, then it would be clear that as the greater the sectional area, the larger the Leyden arrangement would be, there would be more retardations with larger conductors, as more electricity would be required to charge them. He maintained that,

Digitized by Google

Digitized by Google



HOUGHAM CHURCH AS AT PRESENT.



HOUGHAM CHURCH AS INTENDED TO BE RESTORED.

JOSEPH MESSENGER, ARCHT.

Digitized by Google

in practice, a submarine circuit was not charged to saturation; the degree to which it was charged statically depended upon the relative balance between the conditions which favoured induction and conduction; if the conditions, as had been stated in the paper, favoured conduction, there would be less statical charge, and a greater proportion of the electrical impulse would be directed forward, and signals would be obtained more quickly. Mr. Siemens, when considering the question of the complete metallic circuit *versus* the earth for one-half of it, objected to the fairness of the diagram in which one of the conductors was made into a tube. This diagram was introduced, as was stated in the paper, as an exaggeration, simply to shew the fallacy of the principle; and although, as was stated by Mr. Siemens, the wires would not when side by side present as much surface to induction as an ordinary circuit, yet it must be borne in mind that there would be just twice the resistance of that which would be opposed when the earth was employed for one-half of the circuit, and this would more than counterbalance the lessened surface exposed to induction. He agreed generally with the remarks made by Mr. Wray. There was no doubt that with large conductors imperfect insulation was less felt, but the result in Sir W. O'Shaughnessy's case was probably not altogether due to the size of the conductor, for it must be remembered that the climate was very hot and dry. As a practical fact, he (Mr. Varley) would state that when in the Crimea they never obtained what telegraphists termed a "perfect earth." In the submarine circuit between Varna and Constantinople, contact with the earth was made by connecting a wire to the iron sheathing of a piece of the cable, more than a quarter of a mile in length, which was buried in the earth, and passed through the British Embassy grounds, yet, notwithstanding this extensive surface, in hot weather he found the earth, to use a telegraphic expression, very far from "perfect," and he remedied this by carrying a wire out into the Bosphorus.

HOUGHAM CHURCH, KENT.

(*With an Engraving.*)

This church, dedicated to St. Lawrence, appears to have been built at different periods during the eleventh and twelfth centuries. The walls, chiefly of flint, vary from three to five feet in thickness. The south wall of the nave is undoubtedly the most ancient portion of the edifice, and contains a plain semicircular arch, without ornament or moulding. The arch of the tower is Anglo-Saxon, and of a later date, while the west doorway is Norman; the chancel arch unfortunately no longer exists. The windows are Early English lancets, splaying widely inwards with a hood round the arch; the chancel and north aisle have handsome triple lights at the east end, but in the former they have been closed up. From the appearance of the ground outside it would seem that the north aisle was once prolonged to an equal extent with the chancel, instead of terminating as at present with the nave; this, however, is mere conjecture. The doorway belonging to a rood-screen, and one corbel, are visible in the interior, but simplicity of design and the absence of elaborate ornament constitute the principal features of the building. In these particulars and in the pattern of the king-posts, as well as its general aspect, the interior of this church much resembles that of St. Peter ad Vincula in the Tower of London. The church contains two curious monuments: one to Sir William Hanington, governor of Dover Castle in the reign of Henry VIII.; the other to the family of Nepueu.

The tower, which contains three fine-toned bells, one of them bearing the date of 1634, has been twice lowered, at what date is not exactly known, nor what was the form of its summit. It is about to be rebuilt with a broach, as represented in our engraving, through the munificence of Steriker Finnis, Esq., from designs by Mr. Messenger, of Folkestone. The west and south walls are to be faced afresh in black flint, dressed with quoins of Kentish rag; for the windows and doorways Caen stone will be employed. The interior below the ceiling of the belfry will be thrown open to the nave, and furnished with seats for the children of the parochial school. At the same time the nave is to be restored by subscription, new lights being inserted in the windows, and the stonework, which is much dilapidated, cleaned and repaired throughout. In addition, a brick drain 3 feet in depth will be carried round the building, to preserve it from the damp caused by the accumulation of earth. The total restoration will cost about £500, and is to be commenced immediately.

ON THE RECENT IMPROVEMENTS IN PARIS.*

By Edward l'Anson.

Although Paris is well known to most of us, it has occurred to me that a general account of the great works which have recently been carried out in that city may still be interesting. Much has been done since the cessation of Napoleon Buonaparte's wars to improve the principal towns throughout Europe, In London, for instance, immense and thickly populated districts have sprung up; but Paris has changed in another manner, and on all sides of it buildings of importance for their magnitude, and of the highest interest as works of art, have been erected. Thirty years ago the magnificent Place Louis XV. was a vast plain of mud in winter and of shifting sand in summer; and the ground now occupied by the new works of the Tuileries and of the Louvre was encumbered with irregular streets of closely packed houses, booths, and mean shops. The colossal works begun by Napoleon I.—the Arc de l'Etoile and the church of the Madeleine—were still surrounded by scaffolding; and the massive Fountain of the Elephant on the Place de la Bastille, a project since abandoned, was only a model in plaster. Some great works however had been done; the Pantheon, some of the bridges, the column on the Place Vendôme, and the Rue de Rivoli, had been commenced. With these exceptions Paris could not then have materially changed in aspect since the time of Louis XIV. Scaffolding still masked these works in 1830, when Louis Philippe became king, by whom after a time the completion of the public monuments was taken in hand, and measures I believe were contemplated for extensive municipal improvements. Despite some incongruities he had a very grand town to deal with, containing features which marked it as a monumental city as well as a great metropolis. Among the works undertaken by him was the completion of the Arc de l'Etoile, which had been commenced in 1806, after the battle of Austerlitz. The work was confided to M. Blouet, and vigorously carried on till its completion in 1836, at the cost of £417,812. The central archway is 90 French feet high by 45 feet wide; the total height of the monument is 152 (162 English) feet, and the breadth and depth are respectively 137 (148) feet by 68 (72) feet. The whole is impressive chiefly on account of its colossal proportions, and the mass and solidity of its parts. In addition to some noble colossal sculpture, it is covered with the names of the warriors who accompanied Napoleon Buonaparte in his various campaigns, and of the battles in which they were triumphant. On reading them the beholder is impressed with the conviction that the names graven on a monument so grand and durable will defy both the destructive power of man and the slow decay of ages, and pass down in honour to the remotest time.

The church of the Madeleine was finished under Louis Philippe by the architects Vignon and Huvé. This building is also of great dimensions, being 328 English feet in length by 128 feet in breadth. The cost amounted to £523,160. The podium supporting the columns, which are nearly 50 feet high, rises 12 feet 9 inches above the pavement. The general plan is that of a peripteral temple, with an octastyle portico. The effect of the exterior is imposing, but it is far from being a refined work of art,—the mouldings and the proportions of the various parts being generally coarse and commonplace. The frieze is decorated with sculpture; but the usual right line at the angle being broken by the continuation of the enrichment, a singularly weak and disconnected appearance is given to the profile of the entablature when seen anglewise. The figures placed in the niches between the columns round the cella are but indifferent works, but the detail of the doors and architrave of the principal entrance is of exquisite beauty. The flowing ornament on the architrave is of thoroughly French renaissance character, executed with delicacy and breadth hardly attained by the cinque-cento artists; and it is moreover a remarkably fine specimen of casting. The doors and architrave, which are I believe of bronze, were designed by Triquetti, and cast by Richard Eck and Durand. The doors are only inferior in size to those of St. Peter's at Rome. The interior is to my mind more satisfactory than the exterior, though it is not in congruity with it, as it consists of three square compartments, each covered by a dome with openings for light. This plan is not that to which we are accustomed in a Christian church,—it is neither basilican nor cathedral; nor does it, as I have said, correspond with the external features of the building.

* Paper read at the Royal Institute of British Architects.

Digitized by Google

The effect however is rich and grand, and some of the minutiæ are beautiful,—as the metal railings to the chapels, the baptismal font, and the organ case.

One of the first works of the reign of Louis Philippe was the great column of the Place de Juillet, built as its name implies in commemoration of the three days of July 1830. It consists of a column of bronze, raised on a plinth of masonry, a bronze figure crowns the whole, and brings the total height to 160 feet English. The total weight of bronze used amounted to very nearly 407,000 lb.

The Ecole des Beaux Arts, begun in 1832 by Debret, was carried on by Duban. It contains one of the best modern frescoes, or rather wall paintings, by Paul De la Roche, for which he received £3200. The building cost £140,600. The Conservatoire des Arts et Métiers, for which in 1846 a sum of £57,648 was voted, was commenced under the direction of Lèon Vaudoyer, architect. The church of Notre Dame de Lorette, begun in 1823 by Lebas, was completed; but the beautiful fresco decorations of the interior have been added more recently. The total cost of this building is said to have been about 1,800,000 francs.* One year later the still larger church of St. Vincent de Paul was begun from designs by MM. Lepère and Hittorf: it is remarkable for the introduction of polychromatic and profuse mural decoration, of stained glass windows, &c., at a cost of 256,300 francs. The enlargement of the Palais du Luxembourg was carried out at a cost of £120,000. The character of the exterior of the old part by De Brosse was studiously preserved by the architect, M. Gisors. In 1836 the municipality commenced the embellishment of the Place de la Concorde, and of the Champs Elysées. In 1836 the Luxor obelisk was also erected in the Place de la Concorde, having been transported from Egypt and fixed at a total expense stated to be about two millions of francs. In 1844 the Fontaine Molière was erected from designs by Visconti; and subsequently an elegant fountain was erected on the Place Louvois. In 1845, very important works, although not absolutely in Paris, namely, considerable additions to the lunatic asylum at Charenton, were completed by M. Gilbert, architect, at a cost of £132,800. About this time M. Hittorf erected in the Champs Elysees a circus peculiarly well suited to its purpose. I may also mention the elegant façade of a small theatre on the Boulevard du Temple, now the Théâtre Historique, but then the Théâtre Montpensier.

Another work begun by Louis Philippe is the church of Sainte Clotilde, erected in memory of his youngest daughter. He also built on the spot where his eldest son the Duke of Orleans met his melancholy death, a small chapel dedicated to St. Ferdinand. The architects employed were Messrs. Lefranc and Fontaine, who erected a work very inferior to anything, I think, our revived mediæval tastes would have erected even at that time. It is however principally remarkable for the scenic effect of the interior, produced by the skilful grouping of sculpture and painting, and the management of the light: amongst the sculpture is a representation of a kneeling angel, the work of his deceased sister Marie, who little thought when she wrought it on whose tomb it would be placed.

The fortifications of Paris, begun in 1841, are said to have cost £5,650,000. Ten distinct forts are included in the circuit of the walls. In 1848 the mairie of the third arrondissement was begun, and in 1851 the mairie of the eleventh arrondissement was built. In 1850 the fine building of the Bibliothèque Sainte Geneviève was completed, after being in progress about six years. M. Labrouste was the architect; the cost exclusive of architect's charges was 1,569,000 francs. About the same time the very fine and original building, the Timbre Imperial, was completed, at a cost of 1,298,000 francs.

Louis Napoleon, soon after his election as Emperor in 1852, turned his attention to the public works, and since that date the progress of building in Paris has been beyond all precedent, even of the times of Imperial Rome.

I will now proceed to notice briefly the buildings commenced or built during the last six years. Among the early works of Louis Napoleon was the tomb of the Emperor Napoleon I., designed by Visconti, and erected under the dome of the Invalides. It is much enriched with appropriate sculpture, and cost £360,000.

In the early part of 1852, so great was the impulse given to public works, that the following were in progress:—the completion of the tomb of Napoleon Buonaparte; the Hospital du Nord, Clos St. Lazare; the Nouveau Ministère des Affaires Etrangères, begun in 1845, completed a year or two later, at a total cost of £200,000; the works at the Tuileries; the interior decoration of the Hôtel de Ville, and of the church of St. Eustache; the restoration of Notre Dame; the enlargement of the Polytechnic School; the continuation of the Rue de Rivoli to the Rue St. Antoine; the restoration of the Pont Neuf; the completion of the Quai Conti and part of the Quai Malaquais; the station of the Chemin-de-fer de l'Ouest; the new entrance to the Luxembourg gardens; the embellishment of the Champs Elysées; the enlargement of the railway station, Place de l'Europe; the enlargement and decoration of the Palais de Justice; the construction of a mairie for the fourth arrondissement; infantry barracks, Rue Notre Dame des Victoires; the works of the Halle Centrale; the enlargement of the Rue Montmartre, Mathurins, Saint Jacques, Sainte Avoye, De la Harpe, and others; the formation of the Rue des Ecoles; the transferring of the Garde Meuble to the Ile des Cygnes; the completion and decoration of the church of Ste. Clotilde; the Place Belle Chasse; the continuation of the works at the Louvre, and at the Chemin-de-fer de Ceinture; several kilometres of sewers; with the improvement of various hospitals and prisons. In the same year, 1852, the library of the Conservatoire des Arts et Metiers was opened; and it was decided to erect a Crystal Palace in the Champs Elysées, a work accomplished in the year 1855*; the Boulevard de Strasbourg, leading from the railway station to the general line of boulevards, was opened, the length being nearly 1093 yards and the breadth 105 feet; the restoration of the Louvre and its reunion with the Tuileries were begun; the mairie of the third arrondissement, begun in 1848, was finished; and the Jews' hospital was opened.

In 1853, the decoration of the chief apartments in the Hôtel de Ville was completed,; the Jews' hospital, by A. Thierry, was completed at a cost of 400,000 francs; the Palais Royal was entirely restored for occupation by Prince Jerome and Prince Napoleon Buonaparte; the works at Notre Dame were recommenced; extensive works and additions at the Bank of France were commenced; the east works at the Docks Napoleon† were partially finished; the Hospital Lariboisière, begun under Louis Philippe, containing 612 beds, M. Panthier architect, (cost eight million francs) was opened; the iron pipes to convey the water from the reservoir at Chaillot were being laid in the Bois de Boulogne, the lake of nearly ten acres area was almost finished; an iron inclosure was erected at the Hôtel des Invalides, with two new lodges, and the façade of the church was repaired.

In 1854, the works at the Caserne des Petits Pères were recommenced; extensive restoration and repairs of the exterior and interior were begun at the Palais de Justice, the houses which surrounded the building on the west and on the south having been removed; the bridge of Austerlitz, built of iron in 1830, being much out of repair, was rebuilt of masonry in the space of three months, at a cost of £38,000; and the beautiful building, the Cirque Napoleon, was erected by M. Hittorf, in the short space of nine months, at a cost of £27,000.

In 1855 a new municipal building, covering a superfices of 1500 metres was commenced, at an estimated cost of 627,043 francs, by M. Baltard, architect. The works and additions at the Bank of France were terminated; the additions by M. Gabriel Cretin, architect, costing £80,000, and covering a space of 9750 feet; and the restoration of the tower of St. Jacques was completed at a cost of £40,000, in addition to £10,000 for purchasing it. In 1856, the removal of the sheds and buildings surrounding the Palais des Thermes was in progress; the municipality voted the funds for reconstructing the prefecture of police, under Messrs. Gilbert and Diet; the Gothic church of Sainte Eugenie, M. Boileau, architect, was completed; the pavilions of the new Louvre were covered with scaffolding, newly erected, in order to execute further decorations; the covered ways of the Halle Centrale were finished; the vast space comprised between the Place du Louvre, St. Germain l'Auxerrois, the Quai de l'Ecole, the Rue de l'Arbre Sec, and des fossés St. Germain, was cleared away and laid out; the buildings for the Manutention Militaire were finished; the new wing of the Ecole Militaire was in progress; the Pont de Jena was decorated with four equestrian statues; the decoration of the Pont des Invalides was completed; and the buildings about the church of Saint Eustache had been entirely

* The French metre = 3·28 English feet. The Paris foot = 1·066 English foot. 1,000,000 francs = £40,000.

* The surface utilised, including all annexed buildings, was computed to amount to 124,804 metres. The area of the building in Hyde-park was about 72,000 metres.

† The works are still in progress; during the last twelve years a sum has been expended on them of 22,000,000 francs.

Digitized by Google

removed. In 1857, the church of Sainte Clotilde, M. Gau architect, begun in 1846, was completed; the garden round the Ruine des Thermes and Hôtel de Cluny was inclosed by an iron railing; and the additional works at the Hôtel de la Monnaie, built in 1768, were finished. The following works were in progress:—the Boulevard de Sevastopol, which then extended from the Strasbourg station to the Rue d'Ecole de la Madeleine; the Boulevard du Prince Eugene, between the Barrière Poissonière and the Boulevard du Temple; and the demolitions on the left bank of the Seine for the boulevard from that of Sevastopol to the Jardin des Plantes; the vast Caserne du Chateau d'Eau on the Boulevard St. Martin; the picturesque promenade or square of the Quartier du Temple; and the works of the new Louvre were completed. The Fontaine du Palmier was removed bodily, and placed centrally upon the Boulevard de Sevastopol. Very extensive restorations and some new works were in progress at the Bibliothèque Impériale, giving it quite a new character, and reviving a style of architecture with red brick facings and stone dressings, which seems at present rather in vogue in Paris, and which M. Labrouste, the architect to these restorations, has successfully applied in an hotel built for M. Achille Fould. The demolition of the old and construction of the new bridge of St. Michel; and also a temporary bridge undertaken, like the removal of the Fontaine du Palmier, as part of the works of the Boulevard de Sevastopol. In 1857, the church of Sainte Eugene, M. Boileau, architect, was completed. It is built of stone and iron, and exemplifies the great difficulty of satisfactorily combining these materials. The mullions and trefoils of the windows are meagre, and yet not sharp; the effect of the internal columns is poor and without elegance, and the interior generally recalls to mind the interior of a railway station rather than of an ecclesiastical building. The internal light is however well managed, as is also the iron construction of the roof. In the same year the south façade of Notre Dame was entirely restored, the apse had been repaired, and the restoration of the north façade was in progress; the restoration of the roof and the upper part of the Sainte Chapelle externally were finished, and the works were proceeding in the interior; the churches at Villette and Vaugirard had been built, and that at Belleville was in progress; the hospice founded by the Empress, for the reception of poor girls, near the Barrière du Trône, was finished, M. Hittorf architect; the two Hôtels des Invalides Civils, one in the Bois de Vincennes for convalescents, the other in the forest of Vesinet for mutilated workmen, were finished; the Chambre des Notaires was removed to make room for the Boulevard de Sevastopol, and rebuilt on the Place du Châtelet; the Pont des Invalides, of four arches, situated on the site of the suspension bridge, built in 1829, was finished, at a cost of £32,000; and the Pont de l'Alma, of two flat arches, commenced in 1836, was completed.

In 1858, the Boulevard de Sevastopol was opened; the remodelling of the gardens of the Tuileries, a work I believe still in progress, was commenced; the bridge of the Legion of Honour was commenced; the column on the Place de Breteuil was inaugurated, and the Pont du Change demolished; the great barracks at the Chateau d'Eau opened; and the Hospice des Ménages, Rue de Sèvres (proposed to be rebuilt at Issy), removed. Amongst public works now contemplated I find the removal of the great hospitals; the formation of an acqueduct from near Epernay to Paris, at a cost of upwards of £428,000; the formation of a new system of sewerage, at an estimated expense of £140,000; a central tower to the church of Notre Dame; and the removal of the institution of Sainte Perine at Chaillot. The remarkable building called the Halle Centrale deserves a special notice: it comprises ten different compartments in two sections, separated by a boulevard 30 metres wide; the first section occupying 20,000 and the second 10,000 superficial metres. Cellars extend under the whole, which it was intended should be connected with the railways entering Paris, by means of underground railways on the line of boulevards de Strasbourg and du Centre; but this project has been abandoned. Iron, cast and wrought, glass, and brick, are the materials used. The arcades of the front measure six metres in width; the lower part is inclosed with brickwork; above is open glass work, and the upper part has fixed glass work. The employment of cast-iron is here quite legitimate and pleasing in effect. The columns are light and elegant, interfering neither with space, light, nor air, more than is consistent with solidity, in which respect the whole composition is wanting neither in reality nor in appearance. In November 1857, the works of the first part were on the point of being completed, the large tables of white marble being placed in the fish market. The expense of obtaining the land and houses for the Halle Centrale was estimated at 9,141,020 francs, and it required the demolition of 106 properties, occupying a space of 13,262 metres. The construction, with the compensation and the enlargement of the adjoining streets, cost £1,572,000; of which the houses pulled down cost £1,080,000. I must also refer to those essentially modern works, the railway stations, one of which —the Strasburg station—appears to be a model for such buildings. The others are the Rouen railway station, covering a space of 43,000 metres; the Chemin du Nord, covering 44,000 metres; the Lyons, covering 60,000 metres; the Orléans, covering 46,000 metres; the Sceaux and Orsay, covering 9000 metres; and the Chemin de l'Ouest station, covering 24,000 metres. The last named has an iron roof 120 metres long and 30 metres span, the total weight of which is 31,795,588 lbs. The Strasburg railway station in the Faubourg Poissonnière, the work of M. Lermet, engineer, and of M. Duquesney, architect, was commenced in 1847, and finished in 1852, at the cost of the state. It covers 53,000 metres.

	Francs.
The cost for the ground	6,000,000
Earthwork and works of art	1,900,000
The station	2,900,000
Total ...	10,800,000

The length of the façade is 165 feet. The convenient arrangement of the place in front (which is also found in most stations in Paris) deserves especial mention. A spacious court yard, surrounded with iron railings, affords ample room for carriages both coming and going. The building, as a work of art, is of the highest order, and its purpose and use are at once apparent. The roof of the station is very ingeniously and beautifully constructed; it is not perhaps so grand and simple as that of the Great Northern Railway in London, nor so fanciful as that of the Great Western, but it is certainly not inferior in merit to either.

I may also mention, as one of the most characteristic features of Paris, the number of trees which line the great thoroughfares of the boulevards and surround some of the public buildings. Their green colour forms a great relief to the general hue of the masonry; it diversifies the prospect by pleasing masses of light and shade contrasting with the severer lines of the architecture, and gives freshness, coolness, and pleasing variety. In the particular of trees much has been lately done, and instead of waiting for that slow growth by which they would increase, noble trees of twenty years at the very least are planted; thus, round the Bourse I last year noticed that all the old ones which had flourished but ill in the locality, had been replaced by stately trees of ample size, and that in order to preserve them until their roots should get firm hold in the soil, they were swaddled round with woollen bandages, metal hopper-shaped receivers being placed at the upper part of the stem to receive and distribute the water applied to the trunk, kept in a constant state of moisture by means of the woollen wrapper. The new Boulevard de Sevastopol is planted thus with fine full-grown trees, and especial care has been taken with those round the Fontaine du Palmier. The subject of trees leads me also to notice the Bois de Boulogne, and the great works which have there been carried out. This park, which was formerly in a thoroughly neglected condition, was about 1853 handed over to the town on condition that improvements should be made. The first operation was to conduct the necessary water supply to form the decorative lakes. The pump at Chaillot furnishes the supply from the Seine by means of a tube 40c. (16 in.) diameter and 3740 yards long, there are also branch pipes in all directions for watering plants, the roads, trees, &c. In 1854 at least 6200 metres of these smaller pipes had been laid, at a cost of £4000; one lake contains 30,000 cubic metres of water, and the other and larger one, covering an area of 110,000 metres, holds 150,000 cubic metres of water. The level of one lake is considerably above that of the other, so that a waterfall of very good effect is managed on the rocky sides which line the lower one, and for three or four hours during the time of promenade there is a very considerable fall of water. There are many ornamental buildings, lodges, and Swiss cottages. The turf and road are beautifully kept; and the plants and shrubs, many of them of rare kinds, are in excellent order.

Having given a sketch of the several buildings erected of late years in Paris, it may be interesting to record the cost of some of them, this I have already done to some extent, but I will now quote the following:—

Digitized by Google

		Francs.
The Jewish church, by M. Thierry		234,294
Jews' hospital, same architect ...	Ground 65,000	
	Building 96,492	
		161,492
Cost of building, about 80 fr. the square metre.		
Mairie, third arrondissement		389,379
New fourriere or pound for the police		207,752
140 francs the metre.		
No. 60, Boulevard de Strasbourg, private house ...		203,332
651 francs the metre, probably including land.		
New wing, lunatic asylum, Charenton		3,320,000

As more detailed examples, I give the expenses of three buildings —namely, the Circus by Hittorf, the Colonne de Juillet, and a house, Place St. George.

The cost of the circus built by M. Hittorf, on the Boulevard des Filles du Calvaire, was—

	Francs.		Francs.
Masonry ...	194,000	Painted windows	2,500
Carpentry ...	58,000	Furniture ...	20,000
Ironmongery ...	62,500	Lustres and gas...	42,000
Founder ...	15,000	Decorative painting	6,500
Joiner	93,000	Historical painting	10,000
Carving	37,500	Statuary ...	20,000
Stoves	8,000		
Paving and asphalte	16,500		644,000
Stucco work ...	2,000	Design and direction	32,000
Painting and gilding	24,500		
Ornamental sculpture	16,000	Total	676,000
Bronze ornaments	16,000	or	£27,040

The total surface covered by construction being about 1900 metres, the cost per metre amounts to about 350 francs.

The Colonne de Juillet was estimated to cost 1,172,000 francs. The heavier parts of the bronze work was paid for at the rate of 3 fr. 75 c. the kilogramme, and the lighter parts at the rate of 4 fr. 25 c.

The house No. 26, Place St. George, built in 1853, and occupying a space of 1307 square metres, cost 564,000 francs, being at the rate of 448 fr. 80 c. a metre for the ground. The building covers 823 square metres, being at the rate of 237 fr. 35 c. a metre. The cost of the works under the several heads was as follows:

	Francs.		Francs.
Masonry	150,000	Stoves	4,000
Carpentry ...	40,000	Sculpture... ...	13,000
Joiner	50,000	Carton pierre ...	3,500
Ironmonger, smith, and founder ...	33,000	Pavement ...	4,000
Covering & plumber	10,000		534,000
Painting & glazing	18,000	Interest on outlay, and architect's commission ...	30,000
Gilding	8,000		
Paperhanging ...	2,500		
Internal mirrors ...	11,000	Total	564,000
Plate glass externally	7,000	or	£22,560

The income is said on a moderate scale of letting, varying from 900 francs for a fourth floor towards the Rue Laferriere, to 6200 francs for a first floor on the Place St. George, with stabling for two horses, to have realised 39,500 francs, or at about the rate of 7 per cent. on the outlay.

Together with the great public buildings recently erected, and more particularly the junction of the Louvre and the Tuileries, the most important public works which distinguish the era of Napoleon III. are the very striking improvements which have been made in some of the public thoroughfares of Paris, and which in fact give a perfectly new character to a great part of the town. The most remarkable if not the most important is the eastward continuation of the Rue de Rivoli, from the extremity of the garden of the Tuileries to the Place du Louvre, a length of 1300 metres; and numerous cross streets running north and south have been carried out at the same time.

Up to the end of the year 1857 the works on the Rue de Rivoli had cost £4,800,000, and caused the demolition of 800 houses. As part of this work may be also mentioned the square of St. Jacques, and the Avenue Victoria in front of the Hôtel de Ville, at the back of which is now being built, as a pendant to Saint Germain l'Auxerrois, a mairie for the fourth arrondissement. This square occupies a superfices of 6000 metres. The trees and shrubs are of new, rare, and valuable kinds, and were obtained from the first nurseries of Paris, Angers, and Nantes. After the Rue de Rivoli the most important new street is the Boulevard de Sevastopol, commencing at the Strasburg station and extending thence to the Boulevard St. Denis, and passing between the Rue St. Martin and the Rue St. Denis; it then assumes the distinctive name of Boulevard de Sevastopol, and continues until it reaches the Seine at the Place du Châtelet. Up to this point the expense is said to have been about £320,000. It is intended to carry this boulevard across the Ile de la Cité, and on the other side of the Seine from the Quai St. Michel up to the Hôtel de Cluny. According to the indication furnished by a recent map, it would appear that the work will be continued as far as the end of the Boulevard de Mont Parnasse; its length from the Strasburg station to the Barrière d'Enfer is 6000 metres. An offset from the Boulevard de Sevastopol is the Rue des Ecoles, leading to the Halle aux Vins; it was commenced in 1857; the assumed cost of this street is five million francs. On the north side of the Seine, from the newly constructed Caserne of the Chateau d'Eau as a centre, three streets are contemplated: the Boulevard du Nord to the Barrière Poissonnière; the second to the Barrière du Trône; and the third to connect the Halle Centrale with the Faubourg du Temple. A number of new streets have been formed in the quarter between the Rue Saint Lazare, Rue de Clichy, and Rue des Martyrs, a part occupied a few years ago by gardens and occasional houses. In 1847 a new street was opened in the immediate vicinity of the Bank, in which the fine building of the Timbre Imperial was erected, as also the mairie of the third arrondissement. A new street has I believe been begun from the Place Malesherbes to the Place de Laborde; other streets have I know been formed, particularly towards the Champs Elysées in the neighbourhood of the Elysee Bourbon. Among important projected works may be mentioned a place by M. Hittorf at the Arc de l'Etoile, the Avenue of Neuilly being enlarged to 180 metres. Turning again to the south side of the river, we find a new boulevard running between the Boulevard de Sevastopol and the Quai St. Bernard; the enlargement of the Rue Four St. Germain; the rectification of the Place St. Marguerite and du Carrefour de la Croix Rouge. The expense of the work was valued at £88,800. The Boulevard St. Marie to be made in three sections, from the Rue Royale to the Boulevard de l'Hôpital. Another improvement will be the widening of the Rue Mouffetard; besides which I see two other great lines of street are traced. I have now only mentioned the most recent streets of Paris or those in immediate contemplation; but there are other works of the last thirty years, such as the annexation of the Ile des Cygnes to the adjoining land, the Boulevard Mazas, and the Rue Lafayette, which are of very considerable importance.

In order to form these new streets, the law under which expropriation, that is compulsory sale, takes place, was passed as it now stands on the 3rd of May, 1841. It has been completed or supplemented by several regulative ordinances and by a decree of the Pouvoir Executif, having all the force of law. The expropriation takes place on the report of local commissioners, and the compensation is assessed by a jury who sit as judges of the value.

THE FRENCH EXHIBITION

Attracts this year, as usual, a large number of visitors. The subjects are for the most part not of a class suited for our special notice, but it may be remarked that as a collection it will maintain the prestige of former seasons. Perhaps the most popular name in the catalogue is that of Madlle. Rosa Bonheur (19, 20, 21), who has three small pictures, each good in its way, especially the former. It is evident that animal painting is more her *forte* than foliage or verdure. A very large picture in her more usual style forms one of the chief attractions of the gallery; it is by Brion, and numbered (31). The title, "Early Morning on the Rhine," gives little idea of the scene depicted, which is a group of individuals and cattle gliding down the river on a floating raft. The composition of the whole is excellent, and the perspective foreshortening admirably preserved. We may also mention, as another picture of this class, Constant Troyon's "Country Fair in France (147), which is boldly treated, and characteristic.

Some exquisite studies by Bida (13, 14, 15, 16), cannot fail to arrest the eye. The first of these is the property of H.I.M. the Empress Eugenie, and represents "Egyptian Recruits removed from their Village." Eastern incidents appear to be favourites with those artists who do not confine themselves to *genre* productions. Thus we have, in (12), a large and beautiful view near Cairo, with a herd of cattle returning home; (63) is a kindred theme, "Caravan Crossing the Desert"—one of Theodore Frere's numerous and masterly contributions. Two others by the same

Digitized by Google

hand are (65, 66), depicting Egyptian life in "coffee-houses," while (67) renews our acquaintance with the pyramids of Gyzeh, and (69) with the Temple of Karnac. Almost the only really classical work is a small one by Couture (41), the subject of which is the "Decadence of Rome," illustrating a scene of luxury and frivolity. Perhaps the most masterly and touching picture of its kind is by M. Gallait (74), portraying the "Brussels Archers paying the last respects to the Counts Egmont and Horn," in which every part is rendered with painful accuracy. Among productions of another kind may be mentioned (30) "Rembrandt in his Studio," which for its minuteness of detail is worthy of a place among the old Dutch or Flemish masters. The four pictures (apparently serial) by E. P. Frere (57, 58, 59, 60), and entitled, the Toilet, the Breakfast, the Artizan's Family, and the Cut Finger, which are, each and all, charming little gems;—the "Evening Prayer" (75), which reading might be exchanged for "a study of reflected lights;"—(172) "the Young Artist," by Florent Willems;—"the Last Prayer" (143), N. Tassaert;—a pretty pastoral landscape (94), "Near Haarlem, Holland," by Lambinet;—and the two important works by Henry Leys (108, 109), representing Wiesseling, the carpenter of Antwerp, secretly expounding the Scriptures in the early days of the Reformation; and a "Scene from the Siege of Antwerp," in which a lady is shown interceding for the preservation of a church. (174 and 175) are familiar views from Venice, in which more than ordinary attention has been paid to the architectural detail: they represent the "Place St. Marc," and the well-known palaces which line the Grand Canal at Venice.

THE PARALLELOGRAM OF FORCES.

By Arthur Cohen, B.A., Magd. Coll. Cam.

Almost all those proofs of the parallelogram of forces which are not founded on dynamical principles involve either the solution of a functional equation, or the assumption of some mechanical principle extraneous to the consideration of the equilibrium of an isolated point or particle,—such as, for instance, the principle that the point of application of a force may be transferred to any point in the direction of the force. I propose then in the first place to give a proof which neither involves the solution of a functional equation nor the unnecessary assumption of any mechanical principle; and in the second place to show how the problem may be reduced to the solution of an extremely simple functional equation.

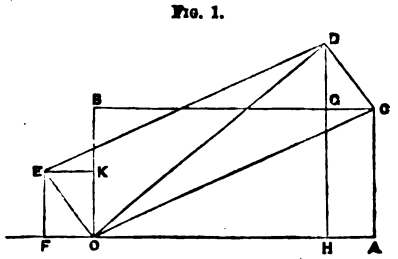
It is easily shown that the only difficulty in proving the parallelogram of forces lies in finding the direction of the resultant of two forces at right angles to one another, and that the angle which such resultant makes with either of the component forces depends solely on the ratio of the magnitude of the two component forces.

If then P and Q be two forces at right angles to one another, and if $\tan(\alpha)=\frac{Q}{P}$, then the direction of the resultant depends only on $\frac{Q}{P}$ or on α. Let then the system of forces P and Q, for which $\alpha=\tan^{-1}\left(\frac{Q}{P}\right)$ be called "a system (α)"

It is clear from the above that if the law of the parallelogram of forces is true of *one* system (α), it is true of *every* system (α). I proceed to show that if the law is true of a system (α) and of a system (β), it is true of a system $(\alpha+\beta)$.

Draw OA, OB at right angles to one another, to represent a system of forces (α) fig. 1; and completing the parallelogram OBCA,

Fig. 1.



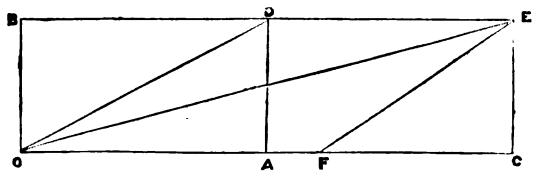
draw OC and OE at right angles to one another, to represent system of forces (β). Complete the parallelogram OCDE, draw OD, and draw DGH and EF perpendicular on OA, and OA produced. Since by hypothesis the law is true of forces OA, OB, and of forces OC and OE, OC represents the resultant of forces OA and OB, and OD represents the resultant of forces OC and OE.

Draw EK perpendicular on OB, then it is evident that OF and OK represent a system of forces (α), and therefore OE represents the resultant of the forces OK and OF. Therefore the resultant of forces OE and OC or OD is the resultant of forces represented by OB+OK and OA−OF, or by HD and OH. But forces OH and HD represent a system $(\alpha+\beta)$; therefore the law of the parallelogram of forces is true of a system $(\alpha+\beta)$. *Q.E.D.*

Secondly, I will show that if the law is true of a system (α), it is true of a system $\left(\frac{\alpha}{2}\right)$

Draw OA, OB to represent a system of forces (α); complete the rectangle OADB: draw OD, and draw OE, bisecting angle DOA and meeting BD produced in E. Draw EF parallel to OD to meet OA produced in F, and draw EC parallel to OB to meet OA produced in C. Since angles DOE and EOA are by

Fig. 2.



construction equal to one another, therefore angle DOE=DEO, therefore OD=DE=OF, and it is clear that FC=OA; therefore the resultant of the forces OB and OC is the resultant of forces OB, OA and OF, or of OD and OF; and since OD=OF, it is evident that OE bisecting the angle DOE is the direction of the resultant of OF and OF. Therefore the resultant of OB and OC is represented in direction (and therefore, as may be easily shown, also in magnitude) by OE. Therefore the law is true of the system $\left(\frac{\alpha}{2}\right)$, which is represented by OB and OC. *(Q.E.D.)*

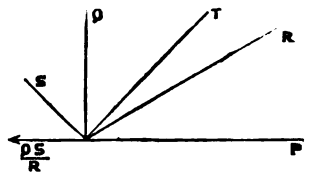
Combining this and the preceding proposition together, it follows that if the law is true of a system (α), it is true of a system $\left(\frac{m\alpha}{2^n}\right)$, whatever integers m and n may be. Now θ, whatever θ may be, may be made equal to or as nearly equal to $\frac{m\alpha}{2^n}$ as we please, by taking n sufficiently large; and we may thence prove by the ordinary *reductio ad absurdam* that the laws of the parallelogram of forces is true of any system (θ).

I will now give another proof of the same proposition by means of a functional equation.

Let P and Q represent a system (α), so that therefore $\tan(\alpha)=\frac{Q}{P}$, and let the resultant R make with P an angle θ. Assume $\theta=F(\alpha)$.

Apply a force S at right angles to R (fig. 3). Then if we suppose a force $\frac{QS}{R}$ to act in direction opposite to P, and a force $\frac{PS}{R}$ to act in direction of Q, it is clear that these two forces having for their ratio $\frac{Q}{P}$ form a system (α),

Fig. 3.



and therefore the direction of their resultant will make with the force Q the same angle that R makes with P; therefore such resultant will be at right angles to R, or S will be that resultant.

Let T be the resultant of S and R, or of $Q+\frac{PS}{R}$ and $P-\frac{QS}{R}$

Digitized by Google

Let T make with R and P angles ϕ and ψ respectively. Let also $\tan(\beta)=\frac{S}{R}$; $\tan(\gamma)=\frac{Q+\frac{PS}{R}}{P-\frac{QS}{R}}$. Then $\theta=F(\alpha)$; $\phi=F(\beta)$; $\psi=F(\gamma)$ and $\psi=\theta+\phi$. Now $\tan(\gamma)=\frac{\frac{Q}{P}+\frac{S}{R}}{1-\frac{Q}{P}\cdot\frac{S}{R}}=\tan(\alpha+\beta)$. Therefore $\gamma=\alpha+\beta$.

Therefore $\psi=F(\gamma)=F(\alpha+\beta)=\theta+\phi=F(\alpha)+F(\beta)$. Therefore $F(\alpha+\beta)=F(\alpha)+F(\beta)$ ... ... (1)

Differentiate this equation first with respect to (α), then with respect to (β), and we obtain $F'(\alpha)=F'(\beta)$; $\therefore F'(\alpha)$ is constant; $\therefore F(\alpha)=A\alpha+B$, A and B being arbitrary constants. Substituting in (1) we find B=0; and since when the forces are equal $\alpha=\frac{\pi}{4}$ and the direction of the resultant bisects the angle between the two equal forces; therefore $F\left(\frac{\pi}{4}\right)=\frac{\pi}{4}$. Therefore A=1, and therefore $F(\alpha)=\alpha$ or $\theta=\alpha$; therefore the resultant is in the direction of the diagonal of the rectangle on the two component forces.

VARIOUS MATTERS CONNECTED WITH ST. PAUL'S CATHEDRAL.*

By F. C. Penrose.

This paper will, I fear, be greatly wanting in unity, as I shall have to enter on different subjects while carrying out the purpose I have in view of tracing rapidly the history of our magnificent Cathedral since it passed out of the master hands of Sir Christopher Wren down to the present time; and then of inviting your consideration of some topics which may have influence on its history for the future. In accomplishing my task, I must claim your indulgence if I am obliged to introduce matters in which I have a personal responsibility. All present are, no doubt, familiar with the history of the commencement, and the general progress of the building during the reigns of Charles II., James II., William and Mary, and Anne. The great architect's task, while steering through the difficulties opposed to him, was no easy one: even during Anne's time he was very shamefully treated,† and continually thwarted by the commissioners appointed to administer the funds, &c.; but after the accession of George I. in 1714, Wren, being then eighty-two years of age, endured for four years continued annoyances from intriguing persons, favourites of the new dynasty, and was finally dismissed from the office of surveyor—still unimpaired in mind, and even sufficiently strong in body to superintend the works; and an ignorant person, named Benson, was installed in his place—a man of such incapacity, that after one year's trial he was ejected. At this time it would appear that almost the only parts of the external structure not completed were the statues on the pedestals, respecting which Wren wrote, Oct. 28, 1717, "The pedestals for the statues I have already laid in the building, which now stand naked for want of their *acroteria*." The balustrade above the general entablature was not, as you are aware, designed by him; and it is probable that it was not executed until after his dismissal. Still it is presumable that when the commissioners insisted on it he may have made the drawings, though under protest, for fear of his design being still more interfered with, if put into such hands as Benson's. So far as the execution is concerned, these late works were worse done, and have given more trouble to keep in repair than any other parts of the structure.

Wren having replied to the commissioners Oct. 28, 1717, protesting against the balustrade, was dismissed April 26, 1718, from his office of surveyor. We may just pause to reflect on the misfortune of political intrigue interfering with architectural appointments, and to indulge the wish that, instead of Benson being made surveyor, Wren's own pupil, Hawksmoor, had been commissioned to assist him; or Gibbs, who has shown in the tower of St. Clement Danes (added to Sir Christopher's church), that he well knew how to combine his own work with that of his great master. The addition, however, of the balustrade over the main cornice, and the omission of the vases on the piers of the balustrade over the colonnade of the dome, are but slight matters in the general aspect of the Cathedral; and we may indeed be thankful that in its integrity the external design, as executed, displays the intentions of Sir Christopher Wren. The building cost in round numbers £750,000, and the works were in hand during the period of forty-four years under his actual superintendence.

A longer period of the great architect's presiding care could hardly have been hoped for; but had the funds exceeded the moderate average of £17,000 a-year, some portions of the work might doubtless have proceeded more rapidly, and his views for the embellishment of the interior might have been carried out more or less perfectly. We are not acquainted in detail with these views, but we know that mosaic work and marble decoration entered largely into them, and we cannot doubt that the whole interior would have corresponded in magnificence with the exterior.

It is impossible to say how far Sir James Thornhill acted in concert with Wren, when painting the cupola of the dome. All that can be stated is, that in the year 1711 the latter writes despondingly about it. "As for painting the cupola, your lordships (the Archbishop and the Bishop of London) know that it has been long in consideration; that I have no power left me concerning it, and that it is not resolved in what manner to do it, or whether at all." This was written in 1711, Sir Christopher Wren being eighty years old. Again, the decoration by Thornhill is quite different from the coffered arrangement of Wren's first model, and from that shown in an early print. On the other hand, Thornhill seems to have been on friendly terms with Wren; for he was employed on his works at Greenwich, and at his college of All Souls, Oxford.

However, considering the barocco style of Thornhill's decoration, I think Sir Christopher's wishes could hardly have been consulted, and we may be thankful that more, such as is shown in Gwyn's section, was not done; for, however naked the interior may appear at present, it does not shock by reason of any tawdry effect; and should the public subscriptions, now invited for the purpose of carrying out a suitable embellishment in accordance with the views of Sir Christopher Wren, flow in with sufficient spirit, it will be possible to ensure a vastly superior effect by following such examples as St. Peter's, and Sta. Maria Maggiore, instead of the fashion of the beginning of the eighteenth century.

To proceed with the history of the building. There seems to have been little done after Sir Christopher left it, till towards the end of the last century, when, under the surveyorship of R. Mylne, apprehension was felt for the safety of the fabric, arising from settlements chiefly apparent in the north and south transepts; and large iron ties were introduced into the walls at the level answering to the triforium of Gothic cathedrals. So far as I can judge, these ties have either arrested the threatened injury, or, the cause of it, viz., the compression of the substratum, having arrived at its maximum, there are no present grounds for apprehension. Should, however, any deep cuttings, *e. g.* for a sewer, be formed in the immediate neighbourhood (one was actually commenced in 1831, which would have passed twenty feet below the level of the foundation, and only fifty feet distant, but was fortunately stopped by Mr. Cockerell's vigilant resistance), there would again be cause for alarm. At present, owing to Wren's admirable precautions, and the care taken of the fabric by such surveyors as Mr. Mylne and Mr Cockerell (care, it is to be hoped, which will never be wanting when necessary), the fabric is in a remarkably sound condition, and the small amount of displacement of the stones, visible here and there, is no more than is inevitable in so solid and lofty a structure founded on the London clay.

There does not seem to have been anything done towards the embellishment of the interior, except a pulpit by Mr. Mylne, and an alteration in the front of the organ screen (making, perhaps, rather too much of the original modest panel dedicated to Wren's memory, "Lector si monumentum requiris circumspice,"—an inscription which has again given place to an expansion of the organ itself) until the year 1821, when Mr. Cockerell superintended the restoration of the decayed gilding and decorative painting at the east end, and at the same time most effectually renovated the ball and the "cross of gold that shines over city and river."

* Paper read at the Royal Institute of British Architects.

† In a curious cotemporary pamphlet—'Frauds and Abuses in St. Paul's'—he, with the master workman and others under his charge, was attacked in a most unjust and unscrupulous manner.

Digitized by Google

During the first twenty years of the present century, however, the walls of the interior have been appropriated to the reception of monuments, good, bad, and indifferent; which, while they certainly add interest to the cathedral, seem even to enhance the cold aspect of its architecture. An opportunity now offers itself, in the Wellington monument, to combine more colour with the composition, which will, I trust, not be altogether thrown away. The paintings of the cupola having become nearly black and obliterated in many places, have been restored. I had the pleasure of bringing this subject before you in 1852. The zeal of Mr. Parris in undertaking, and his energy, courage, and skill in carrying out this extensive work, are worthy of very great praise. The simple and effective contrivances, his own designs, for supporting himself in his eyrie in the air were well worthy of attention; and the adoption of them will greatly facilitate the execution of whatever may hereafter be done in the way of embellishment to the other vaulted portions of the interior. If however the present more ambitious views,—perhaps rather dreams—dreams that, nevertheless, I will hope may work in the direction of their own fulfilment,—had been entertained at that time, it is probable that Sir James Thornhill's work, which, whatever its merits, must be pronounced only second-rate, would hardly have been followed and restored so scrupulously.

Besides the restoration of the paintings, the only important work executed in or about the cathedral within the last few years, until the recent opening of the dome area for divine service, is the tomb of the Duke of Wellington, and the arrangement of the two adjacent sepulchral chambers containing this and the tomb of Nelson. The tomb of the latter is placed under the centre of the dome, surrounded by eight Doric columns, whose bases were hidden by the floor of the crypt having been raised, for some unknown reason, nearly 2 feet above its original level. The bases having been found on excavating, the pavement was lowered, and the columns restored to their original appearance. The vaulted covering over this part was found to be pierced by a number of lead pipes in the haunches of the groins; the object of these pipes is evident when we remember that, for many years after the rest of the church was finished, the central portion was open to the sky.

The sarcophagus of the Duke of Wellington is composed of schorl porphyry from Luxulian, near St. Blazey, on the Treffry estate in Cornwall. Previously to the adoption of this, considerable time was occupied in endeavouring to obtain from Ireland a suitable material. The Clenony marble from quarries on the banks of the Shannon, near Banagher, King's County, Ireland, was particularly examined for that purpose. Blocks of sufficient size could have been obtained, but difficulties in the undertaking and transport made it necessary to abandon the project. The Cornish material was pointed out by Mr. Warrington Smyth, one of the professors in the Institution of Practical Geology, and Inspector of Mines to the Duchy of Cornwall. The sarcophagus rests upon a basement of granite from the Cheesewring in Cornwall. The name and date are cut upon the side panels of the lower or principal block, and the elliptical bosses at the ends are each inscribed with a cross. In the design the great desire has been that extreme simplicity and solidity should prevail, but that by a careful adjustment of the proportions any effect of rudeness should be obviated. If this combination of ideas has been impressed upon the tomb, the result is chiefly due to the assistance given me by Mr. Cockerell. The length of the sarcophagus is 10 ft. 3 in., the breadth 5 ft. 1½ in., and the height about 6 ft. 6 in. It was cut out of a single stone which was just of sufficient size. After it had been scabbled into the general form, a small steam engine was erected on the spot to saw it in two, and afterwards to rub and polish it. The work of sawing the piece in two lasted day and night, with scarcely any intermission, 42 days. The whole operation took nearly two years. It was finally sent to London by the Rev. E. J. Treffry, and was received at the end of January last year. The amount paid for it on delivery was £1100. I estimated the weight of the larger stone, including a timber frame on which it was moved, at 8 tons, and that of the smaller stone at 6 tons. The sarcophagus was lowered into the crypt through one of the windows on an inclined plane. As soon as it reached the floor, the stage was taken down and reconstructed so as to elevate it to the proper height for rolling it on a level upon another short stage erected over the base of the tomb. For these stages light timbers and frequent props were preferred to heavier framing, as more convenient for re-adjustment. The greater portion was of 6 in. by 6 in. and 5 in. by 5 in. die square timber. The general calculation for the bearings was that the load should be equal to one-third of the breaking weight, and the result showed that it was everywhere amply sufficient, as there were no deflections of any large amount. From watching the behaviour of the timber under this strain, I am inclined to think that trusting two-fifths of the breaking weight would not have incurred any danger, but I should not be inclined to advise a smaller margin. In considering these proportions it must be borne in mind, that the condition of a mass moving very gradually and smoothly is the most favourable to the strength of the material, as subject neither to the increasing deflection resulting from too great a permanent load, nor to the danger from concussion resulting from weight in more rapid motion. The bottom and principal stone was lowered by means of two crabs from a jib, supported by trussed framing independently of the stage. The upper stone, which offered no convenience for inserting the lewis, was slung by two straps passing round horns or ears left on each side, which were afterwards worked to a square shape after the manner of the Greek masons. The ceremony of shutting down the lid of the sarcophagus upon the venerable remains enclosed within it, took place April 15, last year, in the presence of the Duke of Wellington, Lord J. Manners, first Commissioner of Her Majesty's Works, and the Dean of St. Paul's. Mr. Mallcott was the mason. The cost of lowering and fixing amounted to about £120, including the timber stages, and making good the window through which it was lowered.

To return to what more particularly affects the Cathedral itself. It is assuredly a fact of great importance, that during the last few months the great central area of the Cathedral has been opened for evening services, by carrying out at last a plan which the Dean and Chapter have been desirous of achieving for the last eight years, but which recent movements in the church put into their hands the means of effecting. These services have answered to an extent which has given great satisfaction to those engaged in it. It would appear that Sir Christopher Wren from the very first must have contemplated such a use of the interior. Even before the Fire of London, we find him engaged in a plan for forming a large central space in the old Cathedral, by removing the tower which had become dangerous; and we are told he advocated the plan expressly for the purpose of its receiving a large congregation. Again, in the model of his single order, a design preserved till lately in the Cathedral, but now at the Kensington Museum, it is quite evident that the great central space must have been the part intended for the congregation, so that the present use of the dome area is strictly in accordance with his intentions. It may be justly affirmed that it has not hitherto been used. It has, no doubt, two or three times in the century been the scene of great public memorials, thanksgivings, and funerals. And once every year it has been turned into a sort of amphitheatre for the exhibition of 4000 charity children; certainly a remarkable spectacle, but not sufficient to satisfy the full purpose of such a building. It therefore seems a matter of great satisfaction that the present evening services have been commenced, at which upwards of 3000 persons are arranged in great comfort; and it is remarkable how well, on the whole, the voice of the preacher is heard. The pulpit is raised about 7 feet, and a preacher with a good and clear delivery, speaking slowly but not very loud, can be heard by the whole congregation, the most distant part being upwards of 120 feet. With respect to the fittings for receiving the congregation, doubtless in the present commencement there is much that is temporary, and cannot fail to have a mean, unsatisfactory appearance. But should sufficient funds be available, these will be gradually removed; and when handsome marble screens or other suitable inclosures take the place of the present rough barriers, ample opportunity being given to the eye of the spectator to traverse in every direction, there can be very little doubt that the appearance of solemnity from the hallowed use of the place, as well as the scale given by the furniture, will render the interior of the Cathedral very much grander than it was before. Indeed has it not become so already, while much is confessedly incomplete? To admit of these services, the Cathedral has been warmed by Messrs. Goldsworthy, Gurney, and Co., who are also engaged in warming the Houses of Parliament. In the crypt which underlies the whole church thirteen large stoves have been placed; and the air in the crypt is warmed to a temperature of about 66°. There are twenty-three openings formed in the pavement of the Cathedral, each

Digitized by Google

about 4 feet diameter, by means of which a constant circulation is produced; some being made upcasts, others downcasts, by means of a winsail, so that the warm air of the crypt rises by some of these openings into the church, and by others the air having been cooled by contact with the walls, roof, and windows of the church, descends to the floor of the crypt, and thus the circulation is kept up. The flues of the stoves are carried up in the external walls of the Cathedral without any injury to the building, owing to the foresight of Sir Christopher Wren, who has everywhere provided for the due examination of the gutters and downpipes by carrying a passage in all cases under the gutters: the downpipes being carried in shafts each about 2 ft. 3 in. square formed in the hollow of the external walls, and iron steps left in the angles of these shafts. The stoves, without being forced, consume about one chaldron of coke per day; the effect is, that instead of a temperature of about 45° Fahrenheit, which we should probably have had (in a severer winter than the present at this time it would have been about 42°) we have a temperature of 57°, which rises about 2° during the time of service; and if the weather were much colder, the same temperature could, I believe, be maintained, but at a larger expenditure of fuel. All the apertures in the floor of the Cathedral are outside the part were the congregation is assembled, so that the stream of heated air which the congregation throws up is replaced by air moderately warmed, and the draughts, inevitable in so large a building, are deprived of their chilling effects, while they are greatly moderated in force. The whole expense of the apparatus, including mason and bricklayers' work, was about £1250. The floor is covered with Kamptulicon floor-cloth, composed of India rubber and cork, excepting the centre (60 feet) where Manilla matting has been used, with a view to its more ready removal if occasion should arise. To confine the sound of the preacher's voice, the space for the congregation is enclosed on six sides of the octagon by screens of American cloth (known as sham leather). Where the screens are placed, it is desirable, should these services become permanent, that marble screens or cancelli should be adopted, of which a good example is seen in the Duomo at Verona. Almost the whole of the congregation is seated on rush bottom chairs of a very strong description, made by Mr. Skull of High Wycombe. The cost of each was 3s. 4d. delivered. As nearly as possible, 1 ft. in 8 lateral, by 2 ft. 9 in longitudinal space is allowed. The gangways are reduced to a very small space, it having been found that persons are otherwise apt to stand in them, and interfere very much with the rest of the congregation. The chairs not offering so solid a resistance as pews to the congregation in entering and going out, it seems that this reduction of the gangways can be managed without any great inconvenience. The result appears to justify the use of chairs even in point of accommodation; and they certainly do not in any way interfere with the architecture of the Cathedral.

Light is obtained chiefly from a corona of about 800 gas jets, placed round the Whispering Gallery: it is sufficiently strong to render moderately small print easily legible by the congregation. The form of the sounding board is, I think, a novelty, but I am led to believe that it is an approach to the true form for the purpose. The first Sunday, when the Bishop of London preached, his fine clear and distinct voice was very much confused by the echo from the dome. It therefore became necessary to put up a sounding board to stop the inconvenience. Flat sounding boards have been most commonly tried, but they are now generally discarded. A parabolic sounding board behind the preacher has been used with a certain effect, but the advantage is limited to those in the direction of the axis of the curve; and in these cases, action and reaction being equal, the preacher can sometimes hear the criticisms of his audience, if any should be uttered tolerably loud in the proper direction. Besides which, a shell of this description would have had little effect in stopping the objectionable echoes. To meet these difficulties a curve was selected, which has the property of distributing uniformly in every direction so much of the preacher's voice as can be advantageously reflected. The figure is hyperbolic, the axis being perpendicular over the preacher. The diameter is 10 feet, and so much of the voice it receives is reflected as if it came from a point about four feet above the preacher.

It would be interesting to know, but I am not aware that sufficient experiments have been made to ascertain, what amount of sound is reflected from a given material. The harder the material, obviously the better the result. In this case, hard organ-pipe metal has been used. I observed a marked increase of audibility of the voice at a place where the assistance of the reflected sound is obtained over a point equidistant from the pulpit, but too high to receive the reflected wave from the sounding board.

The total cost of these fittings, with other expenses incidental to making the building available for the services, was about £3000.

Up to this time no serious expense has been incurred, except re-glazing the windows of the drum of the dome, and re-gilding the parts originally gilt. Messrs. Powell are engaged upon the windows: the glass chosen is of a very simple character, after a pattern in one of Palladio's churches at Venice; it being felt necessary that these windows should admit all the light possible consistent with its not being too glaring. A richer description of ornamental glass may however be used in other parts, especially in the windows at the east end, and in the great windows at the ends of the nave and transepts. But the embellishment of the church ought not to be confined to or even consist mainly in glass. The chief indications of Sir Christopher Wren's wishes as to the embellishment of the cathedral are drawn from a note in the 'Parentalia.' We read in page 291, "In the aisles the lesser cupolas are both ways cut in semicircular sections, and altogether make a graceful geometrical form, distinguished by circular wreaths, which is the horizontal section of the cupola; for the hemisphere may be cut all manner of ways into circular sections; and the arches and wreaths being of stone carved, the spandrels between are of sound brick invested with stucco of cockleshell lime, and which, having large planes between the stone ribs, are capable of further ornaments of painting if required. The inside of the whole cupola is painted and richly decorated by an eminent English artist, Sir James Thornhill, containing in eight compartments the histories of St. Paul. In the crown of the vault, as in the Pantheon, is a circular opening, by which not only the lantern transmits light, but the inside ornaments of the painted and gilded cone display a new and agreeable scene."

In a note to the last paragraph we find the following information:—"The judgment of the surveyor was originally, instead of painting in the manner it is now performed, to have beautified the inside of the cupola with the more durable ornament of *Mosaic* work as is nobly executed in the cupola of St. Peter's in Rome, which strikes the eye of the beholder with a most magnificent and splendid appearance, and which without the least decay of colours is as lasting as marble or the building itself. For this purpose he had projected to have procured from Italy four of the most eminent artists in that profession. But as this art was a great novelty in England, and not generally apprehended, it did not receive the encouragement it deserved. It was imagined also the expense would prove too great, and the time very long in the execution; but though these and all objections were fully answered, yet this excellent design was no further pursued. The painting and gilding of the architecture of the east end of the church over the communion table was intended only to serve the present occasion till such time as materials could have been procured for a magnificent design of an altar, consisting of four pillars wreathed of the richest Greek marbles, supporting a canopy hemispherical, with proper decorations of architecture and sculpture, for which the respective drawings and a model were prepared. Information and particular descriptions of certain blocks of marble were once sent to the Rt. Rev. Dr. Compton, Bishop of London, from a Levantine merchant in Holland, and communicated to the surveyor, but unluckily the colours and the scantling did not answer his purpose, so it rested in expectance of a fitter opportunity; else probably this curious and stately design had been finished at the same time with the main fabric."

A baldachino over the communion table we do not perhaps require, but that is no reason why coloured marbles should not be introduced: we know we can have them both from abroad and from our own country, and they may be most advantageously applied in the panels; and why should we despair of carrying out the desires of Sir Christopher Wren in respect to the mosaic decoration? There is no difficulty—the island of Murano in Venice still produces the material, not inferior to the ancient, even if our own manufacturers do not surpass or equal it. I know that Messrs. Powell are striving to produce this beautiful manufacture: the method is understood,—certainly it is slow,—but there is no mystery about it. I cannot conceive that there ought to be any insuperable difficulty in making this magnificent

Digitized by Google

Digitized by Google

FIREBOX COAL BURNING LOCOMOTIVE.

Fig. 1

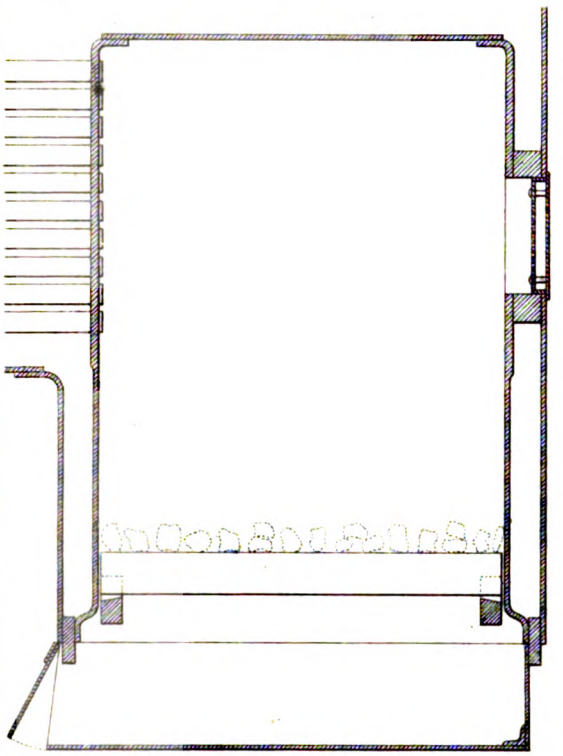


Fig. 2.

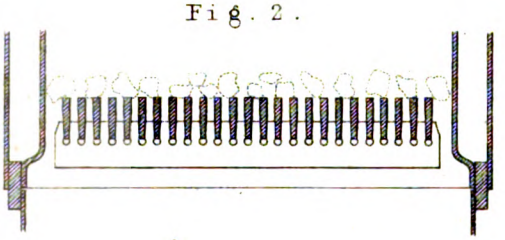
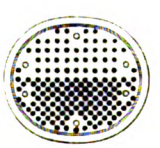


Fig. 3.



Fig. 4.





DIRECT ACTING EXPANSIVE STEAM ENGINE

Fig. 1

Fig. 2

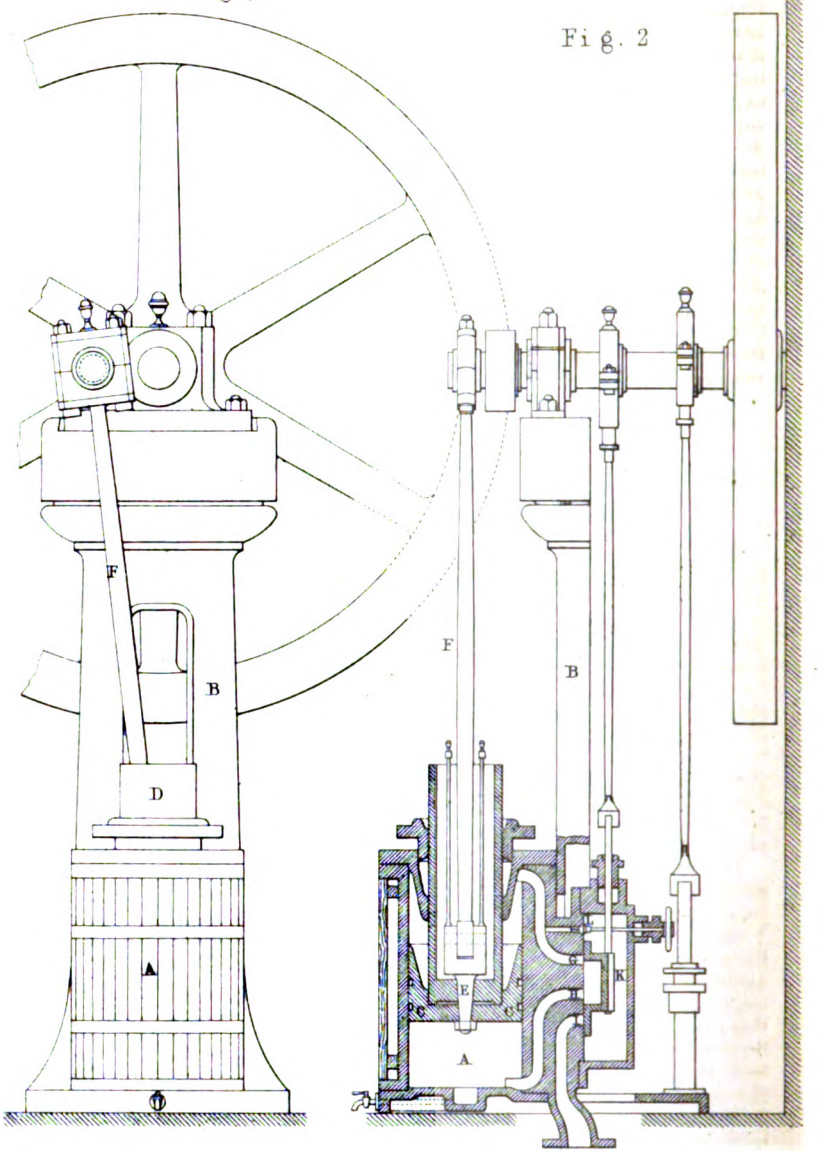




Fig. 5

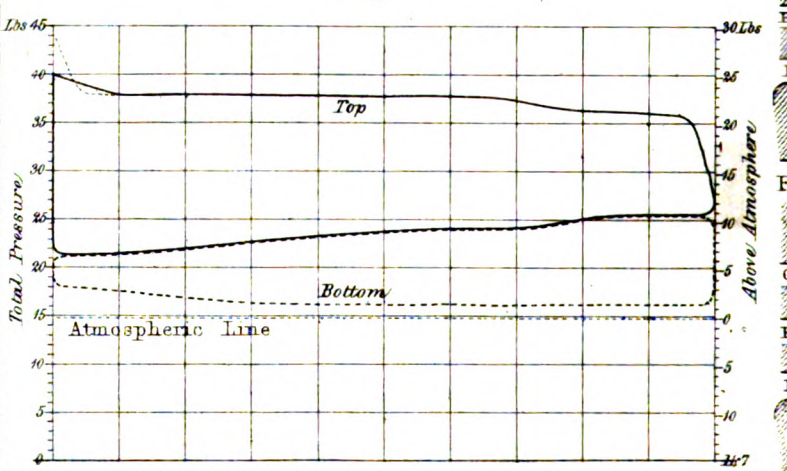


Fig. 3



Fig. 4.



Digitized by Google

interior of Wren's Cathedral brilliant with this forcible but quiet manner of colouring; and the cost of the undertaking cannot be beyond what might fairly be hoped to be contributed in London, many of whose merchant princes could singly do it without impoverishing themselves. I believe that £7000 or £8000 expended in mosaics, would go far to make the drum of the cupola all that could be desired in point of ornament. This would be a commencement, which, if successful, (I do not for an instant question its success,) would most likely lead the way to greater things; a school of workers would have been formed, and the noble spandrils of the eight arches of the dome, and the hemispherical vaults through which the vaults of the aisles are pierced with so much beauty, would offer fit places for more elaborate designs and subjects from Scripture history. This accomplished, there would still be work to do; but by the time thus much should have been done, there would be materials enough collected to form the subject of another paper to be submitted to the consideration of the members of this Institute

ON THE BURNING OF WELSH STEAM COAL IN LOCOMOTIVE ENGINES.*

By J. Tomlinson.

The use of coal in locomotive engines having become almost the rule, the writer offers the following results of a series of trials he has made with the steam coals of South Wales, in locomotive engines upon the Taff Vale Railway, in comparison with the best descriptions of coke to be had in the same district; as there has hitherto been a difficulty in the use of that description of coal for such a purpose almost amounting to prohibition, from the fact that in all previous trials a failure has resulted from the burning of the firebars. This failure of the Welsh steam coal in locomotive engines has been hitherto attributed to the firebars becoming clinkered over; but the results of the trials described in the following paper appear to show that the failure has arisen from an entirely different cause, and one that can be completely obviated.

The writer was originally driven to the use of coal alone for carrying on the traffic of the Taff Vale Railway in January 1858, in consequence of the continued strike of the colliers in the Rhondda Valley, where the coking coal is obtained. Previous to that time little or no coal had been used in locomotives, owing to the good quality and low price of the coke; and from the idea that coal could not economically compete with coke for the heavy work of this line, and also from the known difficulties to be overcome in its employment. The transition from coke to coal being sudden and unprepared for, it became necessary to watch the matter closely, so as to determine which of the various descriptions of coal would answer the purpose best, and to arrange its treatment; more especially as at the outset, from the various qualities of coal that had to be used, the firebars were continually being burnt out, and seldom could be made to last two days without passing through the hands of a smith to be separated and straightened; even then several bars a day were totally destroyed in each engine, some engines having had two entire new sets a day to run 100 miles. After careful consideration of the subject it was decided to use only one description of coal; the preference was then given to the steam coal over the bituminous, as being more pure in its composition, and smokeless; and after attentive observation and trials the Aberdare Four Feet Vein coal was chosen. With this coal it was found that the least damage was done to the firebars, and the best result obtained by working the engine with a very thin fire, say not exceeding 9 inches with a moderate load, and slightly thicker as the load increased, not however exceeding 15 inches in any case. In working with a light train or down hill with a loaded train, it was found advantageous to keep even a more shallow fire than 9 inches; for the blast being very light (as little or no traction is required down hill on this railway), the supply of steam could not be kept up unless the air were admitted with little difficulty; it is however necessary to be prepared in case of being stopped, and therefore a bright fire was a desideratum which could not be obtained unless it were kept thin.

The injury to the firebars was however still a great item, notwithstanding all the care that could be bestowed on them; for it is difficult to get a number of men to attend implicitly to rules which give them more trouble than they have previously been accustomed to. The writer therefore was induced to try an experiment by covering up the entire surface of the bars with small pieces of firebrick, not exceeding 3 inches cube, and putting the fire on them, so as to prevent the direct action of the fire on the iron of the bars; and it was found that from the clean nature of the coal no bad result took place in the generation of steam, while the bars now received little or no injury. Figs. 1 and 2, Plate XVI., are a longitudinal and transverse section of a locomotive firebox, showing a layer of broken pieces of firebrick on the bars. This plan has consequently been generally adopted, but with the partial substitution of clinker from stationary engines instead of firebrick alone. It has completely obviated the difficulty of the bars being burnt, and a set of bars will now last on an average four months, running about 100 miles a day. It is also attended with a beneficial result; for the small coal, instead of passing directly into the ashpan unconsumed; adheres partially to the red-hot brick and clinker, and is consumed; and notwithstanding that the Welsh steam coal falls readily to small, and has little if any binding property, the engines can run 100 miles without cleaning out the ashpan. Another description of coal containing a larger percentage of ash has also been tried for getting up steam and making the first fire to start with, which clinkering slightly on the bars most effectually protected them from burning: the use of this coal was however limited to 5 cwt. per day for each engine.

To place the engine more out of the control of the men, the plan was adopted which had been in use on other engines, of perforating the shield of the firedoor and drilling five or six 2 inch holes in the door itself, as shown in Figs. 3 and 4, so as to admit a little air above the fire; this was found useful not only in assisting combustion but also in preventing the blast from lifting the small particles of coal and thereby choking the tubes.

Having so far succeeded in efficiently working the traffic entirely with coal, and finding the engines were working the trains with a smaller weight of fuel than they had previously done, the writer was disinclined to return to coke without good reason, after the experience he had had. A series of experiments was therefore made to test the commercial value of each description of fuel. The first series of experiments was made with an engine working the regular mineral trains, with Aberdare Four Feet coal and Rhondda Valley best coke: the second series, with the same coal and coke, with a special train of 35 loaded coal wagons weighing 269 tons, run at the regular speeds of the ordinary trains of about 11½ miles per hour: the third series, with various fuels, with a special train of 40 loaded coal wagons weighing 314 tons, run at a speed of 20 miles per hour up the hill and 12 miles down (12 miles per hour being the limit down hill with loaded trains): and the fourth series, with bastard steam coal and Aberdare Nine Feet coal: the former of these has a larger percentage of ash and more bituminous property, the only objection to its use being the smoke: it does not burn the bars, and is fully as economical as the pure steam coal.

The whole series of experiments were made with the same engine and by the same engineman. The engine is of the following dimensions: cylinders 16 inches diameter and 24 inches stroke; six wheels coupled, 4 ft. 6 in. diameter; firebox 3 ft. 6 in. square by 4 ft. 10 in. high; 156 tubes, 13 ft. 3 in. long by 2 inches diameter, and No. 11 to No. 14 wire gauge thickness; safety valves loaded to a pressure of 110 lb. per square inch.

The following table gives the general results of the whole of the experiments, showing the quantity of fuel consumed per ton per mile, the quantity of water evaporated per lb. of fuel, and the average speed of the train during running:—

Description of Fuel.	Fuel consumed per ton per mile.	Water evaporated per lb. of fuel.	Speed in running Miles per hour.
	lb.	lb.	miles.
Coal—Aberdare Four Feet Vein	·127	7·63	11·5
Coke—Rhondda Valley Best Coke ...	·172	7·62	11·5
Coal—Aberdare Four Feet Vein	·130	8·37	11·5
Coke—Rhondda Valley Best Coke ...	·124	8·34	11·3
Coke—Rhondda Valley Best Coke ...	·136	7·54	16·8
Coal—Aberdare Four Feet Vein, lump ...	·133	7·73	16·5
Coal— Do., half lump and half small	·153	7·11	14·8
Coal—Rhondda Valley Bastard Steam Coal	·110	8·63	11·5
Coal—Aberdare Nine Feet Vein... ...	·112	8·15	11 5

* Paper read at the Institution of Mechanical Engineers.

Digitized by Google

The results in the consumption of fuel showing in all cases slightly in favour of the coal, they may fairly be considered equal; and as the abuse of the engine when burning coal is more easily detected than when using coke, this forms a further advantage in favour of coal. The preference may also be given to coal over coke for the freedom in generating steam, which will allow the blast pipe to be of larger dimensions than when burning coke. This has been clearly shown, as the engines are now maintaining steam at 100 to 110 lb. per square inch with coal, with the same sized blast pipes as were used previously for 80 lb. with coke; and the firebars have also been placed closer together, the air spaces being reduced from 1 inch to ⅝ inch. Hence the writer thinks it may be concluded that the Welsh smokeless coal may be economically used in substitution for coke; and that where failures have taken place previously, they are to be attributed to the very great heating power of the coal; and that the difficulty with firebars has resulted not from clinker, but from the absence of a proper protection for the iron of the bars, so that with heavy firing the heat has struck downwards and fused the bars themselves.

Nearly all the engines on the Taff Vale Railway are now burning Welsh steam coal entirely; they take with each train a load of eighty empty wagons averaging 3¼ tons each or 260 tons total, up an average rising gradient of 1 in 309, at from 13 to 14 miles per hour without any inconvenience.

The composition of the Aberdare Four Feet Vein, the coal now in use in these engines, is

Carbon	90·25
Hydrogen	4·12
Oxygen	2·25
Nitrogen, &c.	2·13
Ash...	1·25
	100·00

It is therefore practically coke, and requires only proper treatment for substitution in the place of coke. Another great advantage in the use of this coal over all others in locomotive engines is its almost entire freedom from smoke, thus rendering any plan of smoke-burning unnecessary, not even a steam jet being required when the engine is standing.

The advantage of slow speed is so distinctly shown in the results obtained that the writer considers this point is worthy of more attention than it usually receives on railways; for a slow speed not only economises the quantity of fuel consumed by diminishing the resistance of the train, but also increases the evaporative duty obtained from it.

Discussion.

Mr. TOMLINSON explained that the firebrick was merely broken up into small pieces of about 3 inches cube, and thrown in roughly with a shovel in a single layer over the grate, so as to cover the firebars; it was found to last a long time, and in one special trial that he had made to ascertain its durability the fire was not dropped for six days, the engine running continuously 100 miles per day, and at the end of that time the firebrick still remained as an efficient protection for the grate bars. The thickness of the fire was an important point: it might be 9 or 10 inches thick at the sides, where the absorbing surfaces of the firebox kept down the temperature; but should be as thin as possible in the centre, so that the bars could just be seen through it, for the bars would go down in the centre in spite of all precautions, unless the fire was kept very thin, on account of the intense heat. By the experiments the injurious effect of increased speed was remarkably shown, not only in increased consumption of fuel, but also in diminished evaporative duty of the fuel, which was reduced about 10 per cent. by an increase of speed of 5½ miles per hour, or about 50 per cent. In the trial that he had made of Newcastle coal, he had found that the bituminous Newcastle coal demanded very different circumstances for its economical consumption, requiring a much greater supply of air; it consequently received imperfect treatment in ordinary locomotive fireboxes, where no provision was made for an extra supply of air beyond that admitted through the grate; so that the evaporative duty obtained in the trial was only 5¼ lbs. of water per lb. of fuel.

The results of the trials in consumption per ton per mile were not always thoroughly reliable as a means of comparison, on account of the great fluctuation in the weight of trains down, some being as much as 700 or 800 tons down hill, which would materially affect the result; the fall was nearly uniform from one end of the line to the other, amounting to 409 feet in 24 miles, or an average gradient of 1 in 309. The coke cost 12*s.* 6*d.* per ton and the coal 6*s.* 8*d.* per ton in the wagons upon the railway; so that the cost of fuel when coal was used was little more than half of that with coke, as the consumption was about the same in quantity to do the same work.

Mr. R. LAYBOURN said he had made some trials of burning Welsh coal in locomotives on the Monmouthshire Railway, about eighteen months ago, with coal from Nixon's Deep Duffryn seam, the same seam of coal as the Aberdare Four Feet Vein, but found the bars came down in the way described: this was obviated by using inferior coke for lighting the fire, which formed a portion of clinker over the bars that served to protect them; by this means he succeeded in using the coal. He had made a series of experiments, which led him to the adoption of a considerable proportion of coal mixed with the coke for the locomotives on the Monmouthshire Railways. In the half-year ending December 1855, and previously, coke alone had been used, at an average rate in that half-year of 40 lb. per mile for all the trains, passenger and goods, costing 3·12*d.* per mile of the trains for fuel. In the following half-year to June 1856, a quantity of coal was mixed with the coke; and in the next half-year to December 1856 this was increased to an average of 22·73 lb. of coal per mile and 17·85 lb. of coke, making a total consumption of 40·58 lb. per mile, at a cost of 2·56*d.* per mile of the trains for fuel. The proportion of coal was then further increased, and the results were—

In the half-year ending	Coal.	Coke.	Total Consumption.	Cost of Fuel.
June 1857	39·25 lb.	5·60 lb.	44·85 lb. per mile.	2·09*d.* per mile.
Dec. 1857	39·71	5·20	44·91 —	2·13 —
June 1858	34·15	7·21	41·36 —	2·10 —

He had not tried fire-brick, but by getting up the fires with inferior coke a clinker was formed over the grate, which was found to answer the purpose of protecting the bars.

Mr. TOMLINSON said that the weights given in the tabular statement of experiments were those of the trains alone, independent of the engine and tender, which would add about 45 tons, the engine being about 29 tons weight and the tender 16 tons.

Mr. B. FOTHERGILL had been engaged recently in experiments on this subject, and he agreed entirely with the statements in the paper, as to the efficiency of coal for locomotives in place of coke; and that the quantity of coal required was not greater to do the same work, if suitable provision was made for its proper combustion. His experiments had been made with the partially bituminous coal of Lancashire and Yorkshire; and he had also made one trial with the Welsh smokeless coal in a locomotive engine, but it was impracticable to complete that trial in consequence of the firebars melting down upon the trip, so as to stop the engine after having run only a short distance. It was not from defect of the coal that this stoppage of the trial took place, but entirely from the melting of the firebars; and it was evident that without some provision for protecting the bars from melting, the Welsh smokeless coal could not be employed in locomotives. In two trials he had made, the cost of fuel for taking the same train over the same distance of 96 miles was found to be with coke at 11*s.* 6*d.* per ton, 22*s.* 3*d.*; with coal at 5*s.* 3*d.* per ton, 9*s.* 5*d.*; showing a saving of 57 per cent. in the cost of fuel consumed when coal was used. Locomotive engines using coal might always be made to burn their smoke satisfactorily. A point of great importance was the relative durability of the boiler tubes and firebox with coal and with coke; and after the practicability of using coal with great economy in cost of fuel had been established, this became a serious question in deciding whether to go on making coal-burning engines instead of coke engines. It had been feared at first that there would be a loss from more rapid destruction of the brass tubes and copper firebox with coal than with coke; and he had been recently engaged in an investigation of the subject on the London and South Western Railway, where coal-burning engines had been worked for a long time, for the purpose of ascertaining the real lifetime of the tubes under the two circumstances. The result was found to be that in twenty-six coke-burning engines the average duration of a set of brass tubes was 94,518 miles, varying from 65,000 to 127,000 miles, according to their quality and the description of coke used. But in several engines running with half coal and half coke, the tubes had run 154,955 miles, and were still in good working condition; and in one of these engines the

Digitized by Google

tubes after 137,676 miles' work were not half worn out, and were reduced in thickness only from No. 13 to No. 16 wire gauge, or from ·095 to ·065 inch. From the results of this investigation he was satisfied that the ordinary wear of the tubes was caused mainly by the cutting and abrading action of the hard particles of coke drawn rapidly through the tubes, and was not entirely a chemical action as had been at first supposed; and consequently the comparative softness of the particles of coal greatly reduced this cause of wear. This was illustrated by the wear that ordinarily took place in the fireboxes of coke engines, in which the roof and upper portion were reduced only $\frac{1}{32}$ inch in thickness, whilst under the firedoor and at the lower part of the sides, where exposed to the continued wear of the hard pieces of coke, the thickness became reduced $\frac{1}{8}$ inch in the same time. He was satisfied that the durability both of tubes and fireboxes would prove much greater with coal alone; and that there was no ground to fear more chemical action from sulphur with coal than with coke.

Mr. Tomlinson said that the quantity of sulphur in the Welsh steam coal was very small, and was included in the 2·13 per cent. of nitrogen, &c.; in the Four Feet Vein the proportion of sulphur seldom exceeded from 1 to 1½ per cent., and was never more than 2 per cent.

Mr. W. G. Craig said he was satisfied that the tubes had a much greater durability with coal than with coke. For the purpose of burning coal he had used a firegrate constructed with each alternate bar raised 1 inch above the others, making a kind of hollow fire, leaving spaces for air to enter under the fuel; the bars were not found so liable to burn in that arrangement as with a level grate, being protected by a greater supply of air on their top surface; a set of bars now lasted several weeks with coal, instead of only one week as before when they were all level.

Mr. J. Fenton observed that the low evaporative duty obtained from the Newcastle coal, when burnt without consuming the smoke, showed the great importance of ensuring a sufficient supply of air for bituminous coal, and a considerable larger quantity than was required for a coke fire.

Mr. W. Smith remarked that he had seen a construction of cast-iron channelled firebars by Mr. Gray, in an application of which every alternate bar was raised about 1½ inch above the rest: sloping notches or channels were made across the top edges of the bars, to afford an increased area for supply of air; several sets were at work in London, burning coal, and they appeared to answer satisfactorily, giving an increased supply of air, and lasting longer than the ordinary bars from the greater cooling effect of the air.

Mr. Tomlinson said he had tried a set of Mr. Gray's firebars for a stationary engine grate under a large Cornish boiler, but had not found there was much advantage over a set of thin cast-iron bars which he had tried in a companion boiler of the same description; the latter bars were 3½ inches deep by ¾ inch thick at top and ½ inch at bottom, with ¼ inch spaces. In both boilers the firedoors were perforated in the same manner as the locomotive firedoor, and provided with sliding shutters to close the air holes; there was also a damper below the fire to shut up all close when the incline was not being worked. He thought that in practice the channels across the bars were more frequently filled with dust than clear, and hence the absence of any good effect resulting from them. The bars that he used for locomotives were wrought iron, 4½ inches deep by ⅞ inch thick at top and $\frac{5}{16}$ inch at bottom, and ⅜ inch spaces when new. In some engines the same set had lasted five months when burning about 45 lbs. of coal per mile and running about 500 miles per week: their average duration was about three months, which was gradually increasing.

Mr. R. Laybourn observed that an important consideration in the matter was the great variation in the quality of coal obtained in different districts, so that a special plan had to be arranged on each different railway to suit the coal to be used there. He had made trial of a plan of firegrate by Mr. Jeffreys, of the Shrewsbury and Hereford Railway, in which the bars were laid flatways on the side instead of the edge, with air spaces between, and partly overlapping one another, forming a gradually sloping surface from each side of the firebox down towards the centre; this arrangement proved successful in admitting a larger supply of air, and he found it effective in burning the bituminous coal.

Mr. Maudslay observed that this was similar to Mr. Crampton's firegate, that was used on the French railways, except that in the latter the bars were laid transversely instead of longitudinally in the firebox, forming a surface sloping down from the firedoor towards the tube plate.

Mr. E. A. Cowper observed that in Mr. Gray's plan of firebars that had been referred to, the general arrangement he believed was to have ½-inch bars and ½-inch air spaces, giving 50 per cent. area of opening in plan for the admission of air; but the effective area was increased to 60 or 70 per cent. by cutting sloping notches in the top edges of the bars, so that portions of the top surface of the bars were cut away. He did not know what were the results of their working, but thought the use of very thin bars fully answered the purpose required; he usually employed bars only ½ inch thick at top and ¼ inch at bottom, with ⅜-inch spaces.

Mr. Tomlinson said that a set of Mr. Gray's firebars had been tried for some time in the "Iron Duke" locomotive engine on the Great Western Railway; but he did not think any plan of stepped grate would be suitable for burning the Welsh coal, for he found that if any one of the ordinary bars was accidentally left standing up above the others, from the notch in the firebar-frame not being cleaned out, it was sure to get burnt more than the rest.

Mr. E. A. Cowper had heard that a plan had recently been tried in some locomotives on the Great Western Railway, for tipping up the entire firegrate upon a centre bearing, so as to allow of laying the fresh fuel on the bars, and then covering it over with the red fire when the grate was tipped back again sharply.

Mr. R. Laybourn believed that was Mr. Jeffreys' plan, and was intended as a mode of making cast-iron bars suitable for locomotive firegrates: this was effected by never disturbing the cast-iron bars on their bed, and they were never removed until worn out; but when the fire had to be dropped the whole frame was tipped over on a centre bearing, allowing the fuel to drop out. This plan gave great economy in the cost of maintenance of firebars, as cast-iron was used instead of wrought-iron bars; and the bars were preserved from injury by avoiding the handling of them whilst hot, which was liable to bend or break them.

Mr. J. Fernie said an arrangement of ridged firebars had been tried for a stationary engine boiler at Derby, on Mr. Chanter's plan, in which the top of the bars was ridged or serrated, and every alternate bar was moved longitudinally about 1 or 1½ inch backwards and forwards, the intermediate bars remaining stationary; the alternate bars were moved by a transverse shaft provided with a lever, which was moved occasionally by the stoker. These had been in use about two years, and were found to answer the purpose satisfactorily; the ridges on the bars served to keep the fire gently stirred, preventing clinkers from adhering to the bars.

Mr. W. G. Craig observed that for burning coal it was requisite to have the bars rather close together and very thin, considerably more so than with coke; and the object he had in view in using a grate with the alternate bars raised above the others was to admit more air under the fuel, making a kind of hollow fire, to prevent the bars from burning. The firebars he used were ⅞ inch thick at top and ½ inch at bottom, with ¾ to ⅞ inch air spaces, and when placed alternately raised they could be brought still closer.

Mr. J. E. Clift inquired whether a pan of water had been tried under the firegrate, to prevent the bars being burnt; that plan was frequently used in stationary engines with good results, and by this means he had had firebars in constant use for two years with intense coal fires under gas retorts, without the bars burning away. There was constantly a supply of water under the firegrate, and the steam rising from it served to keep the bars continually protected and cool.

Mr. Tomlinson said he had tried a jet of water from the boiler kept continually running under the firegrate of a locomotive during the whole trip, but it did not serve to protect the bars from burning; he had not tried a pan of water, but with the jet there was so much water constantly supplied as to keep the ashpan full of steam, and he thought the effect would be the same as in the use of a pan of water.

Mr. C. W. Siemens observed that the efficiency of the water below the firegrate would depend a good deal upon the quantity of ashes falling from the fire; if the ashes fell easily they would keep up a supply of steam from the ashpan and preserve the bars from injury; but if much clinker were formed on the firegrate, the water-pan would not answer, as there would not be steam enough to keep the bars cool.

Digitized by Google

DESCRIPTION OF A DIRECT-ACTING EXPANSIVE STEAM ENGINE.*

By Thos. T. Chellingworth.

The very general use of high-pressure non-condensing steam engines makes the economy of their working and construction a matter of considerable importance. There are many cases in which circumstances will not admit of the use of a condenser, such as the absence of a good supply of water without deep wells and expensive apparatus for lifting; or where the work to be done or the capital available will not admit of the expense of a condensing engine. In any of these cases it becomes a most important consideration that economy in the first outlay, which is a frequent reason for the use of a non-condensing engine, should be combined with economy in the working also. The economy obtained with a single slide valve, by giving an additional lap and cutting off the steam at an earlier part of the stroke, can be carried only to a moderate extent, and the use of a separate cut-off valve is found necessary to obtain the full advantages of expansion.

With the view of obtaining simplicity and economy of construction, the writer has endeavoured in the engine described in the present paper, with a single cylinder and a simple slide valve and without any additional valve gearing, to cut off the steam at an early portion of the stroke after having been admitted at a high pressure, and to expand it very nearly down to the atmospheric pressure. The steam is first admitted to the top of the piston, and after having made about two-thirds or three-fourths of the down-stroke, it is cut off and expanded to the bottom of the stroke; the same steam is then admitted to the under side of the piston and expands through the whole of the return stroke; being in fact used in the same manner as if it were cut off at about one-third of the single stroke of a cylinder double the length. In order to obtain this result it is necessary to have a piston with two different areas, the steam being first admitted on to the smaller area and then expanded on to the larger one.

The construction of the engine is shown in figs. 1, 2, Plate XVI. Fig. 1 shows a front elevation, and fig. 2 a longitudinal section. The cylinder A is bolted to the base-plate and also to the standard B by snugs at the back. The piston C is cast in one piece and bored out to receive the end of the trunk D, being secured to it by the bolt E, which also forms the eye for attaching the connecting rod F. The piston is dished and fits into the cylinder cover, leaving only a small space between, the stuffing box projecting inwards; this shortens the height of the engine while it admits of the piston being lightened. The steam ports G and H are placed next to each other; and the exhaust port I, underneath, instead of between them, as in the ordinary construction; the valve K is an ordinary D slide worked by an eccentric and rod; figs. 3 and 4 show the extreme positions of the slide valve. In starting, a difficulty would be caused by a partial vacuum being formed by condensation of the steam before the lower part of the cylinder gets heated; this is obviated by the starting valve L, consisting of a small conical plug which is drawn back by a screw, and opens from the steam chest into the top port G, by means of which the engine is easily started at any point of the stroke.

In this engine the steam is first admitted through the top port G, and acts on the annular space round the trunk D, being cut off and expanding in proportion to the lap of the valve: then in the return stroke the two steam ports G and H are thrown into communication with each other by the inside of the same slide valve, as in fig. 4, and the same pressure acts on both sides of the piston, the return stroke being made by the unbalanced pressure of the expanding steam acting upon the area of the trunk; and during this up-stroke there is no back pressure from exhaust. Fig. 5 shows the indicator diagram taken from this engine, the full line being the diagram from the upper side of the piston and the dotted line from the under side, the bottom line of the one and the top line of the other being necessarily identical; the speed of the engine was 60 revolutions per minute.

The engine as described is working at the writer's works at Westbromwich, and an engine of similar construction at Mr. Dowler's works in Birmingham; in the latter engine the connecting rod, instead of working direct on the crank, is connected to the end of a beam, the present cylinder being in the place of one of the ordinary construction, which has been removed.

* Paper read at the Institution of Mechanical Engineers.

In the Discussion which followed, Mr. Chellingworth said that the engine was about 4 horse power, and worked with 40 lb. steam in the boiler; and it had been eight months at work. He showed the piston and trunk taken out of the engine; the piston had been working at present without packing, with merely a groove turned round the centre to receive a packing ring, the groove being supplied with oil by two small holes from the centre of the piston; the piston was found to work well and steam tight, having a great length to serve as a guide. The consumption had been 21 cwt. of engine slack during a six days' trial of ten hours per day.

Mr. Clift said he had seen the engine at work and had seen the indicator diagrams taken; it worked very satisfactorily, the up and down strokes being nearly uniform, and it ran steadily at a high speed; it was simply a means of carrying the principle of expansion much further in small engines than was usual, with a simple, compact, and very economical construction; and he had no doubt it would be found an efficient engine.

Mr. W. Smith observed that the general arrangement of the engine appeared to be the same as had been adopted in several previous plans of trunk engines, and he did not see any novelty or special advantage in the one now shown; he thought the cylinder should have a steam jacket if it was intended to be economical in working.

Mr. Chellingworth said the only object had been to get a simple and convenient expansion engine, giving a considerable degree of expansion with an ordinary single slide valve, cheap in manufacture and economical in working, and suitable for the cases of ordinary small engines, which were generally very imperfect in economy of steam. A steam jacket had not been used in the present engines, as economy of construction was specially aimed at; but he intended to add a steam jacket where practicable, to prevent the drop of pressure shown in the indicator diagram on letting the steam into the bottom of the cylinder.

Mr. I. Smith remarked that with a flat cut-off slide working on the back of the valve the steam might be readily cut off at any part of the stroke in an ordinary cylinder, by the addition of a simple expansion gear. He had lately seen an engine working at Bolton with a good form of expansion gear of this description, by Mr. Schiele, in which the steam was cut off either very early or later in the stroke as the work to be done required more or less steam, by means of the ordinary governor being connected to the expansion gear, which served to regulate the engine without the intervention of a throttle valve: he had seen the indicator diagrams obtained from the engine, which showed a very high degree of expansion.

Mr. Inshaw said he remembered an engine many years ago, of a similar construction to that described in the paper, in which the trunk was two-thirds the area of the cylinder, and the steam was superheated by means of a firegrate below the cylinder.

THE EXHIBITION OF FEMALE ARTISTS.

The small gallery in the Haymarket, where this—the third—exhibition is now held, is hardly spacious enough for its purpose; so assiduous are our fair practitioners, and so much have they gained in strength as well as numbers. Apart from the motives of mere curiosity which may prompt sundry visitors, there are not a few of the pictures which, besides their intrinsic merit, would otherwise repay examination. Flowers, fruit, and still life appear to be in general the favourite studies; and, as might be expected, these are ordinarily the most successfully handled. We may refer especially to "Wild Flowers" (134); "Spring" (2); "A Study from Nature" (68); "Flowers" (114); "Study in Spring" (167); "Fruit" (218); and "Autumn Fruit" (250); to which are attached the names of Ellen Cantelo, Emma Walter (2), Florence Peel (2), Miss Lance, and Mrs. V. Bartholomew. Some articles of domestic use have been carefully copied in (295); and (235) is a painstaking study of various shells, by Marianne Stone.

(56) Is a very masterly delineation of a Swiss scene, as is an English scene, "Hop-picking at Seven Oaks" (77). An attractive picture, too, is (181), "The Colossi at Sunrise, Thebes," which are invested with becoming stateliness and solemnity. Among the careful "transcripts from nature," (266, 270) must not be overlooked, and others of the same kind will be readily discerned here and there on the walls. (43) "Marie Antoinette at the

Digitized by Google

Conciergerie," by the Hon. Mrs. Monckton Milnes, is a portrait which will be scanned with sympathising interest.

A few drawings, embracing more or less architectural subjects, may be enumerated. A well-known name among contributors of this kind is Miss L. Rayner, who is here an exhibitor of four such pictures—"Christ Church Gateway, Canterbury" (21); Salisbury Cathedral, from Silver-street" (39); the "South Aisle, Westminster Abbey" (120), (scarcely equal to the others); and (229) "Old Houses at Gloucester." There are two other views in Westminster Abbey—one, taken in the "Ambulatory" (74), is by Miss Beale, who is not very happy in indicating Gothic details; the second, on the contrary, is a capital bit of manipulation (110), in which Miss M. Porter reproduces the "Entrance Gates, &c. to Henry VIIth's Chapel." In (7) we have a sunset effect on "Whitby Abbey," in which that venerable ruin is excellently shadowed forth. Rivaulx Abbey, too (62), with its enchanting scenery, finds a skilful limner in Miss M. Stone. Two views of Bamborough Castle (20, 31) are interesting, and nicely coloured. In (30 and 85) Mrs. Higford Burr exhibits two architectural subjects from Verona; the first is a "Tomb in the Pellegrini Church of St. Anastasia," and the second shows the "Pulpit in the Church of St. Fermo," in which a preacher is seen addressing his audience evidently in a strain of impassioned fervour. These drawings are both carefully detailed, as well as being quite artistic in effect. (27) claims our attention as being professedly an architectural subject—"St. Ann's Chapel, Malvern Abbey;" but it is not altogether so successful as could be wished. Nether Hall (97) is better. The "Church of St. Pierre, Caen" (163) is well given; as is the Rue de l'Ecu, Coutance (228). The "View of Fitzroy-square" (111), is careful, but only locally interesting, and the same may be said of (279), "the Old Steyne, Brighton."

INSTITUTION OF CIVIL ENGINEERS.

J. Locke, Esq., M.P., President, in the Chair.

March 29.—The whole of the evening was occupied by the Discussion, commenced at the last meeting, of Mr. Jackson's Paper, "*On the Melbourne Gravitation Water Works.*"

It was remarked that there was a vast number of instances in this country of the collection of water, in a similar manner to that adopted at Melbourne, from drainage areas, generally of a mountainous character, in which the water was received into artificial reservoirs, of sufficient capacity to equalise the irregular rainfall for many years in succession. The present mode of treatment was rather the result of experience than of original reasoning, which for the most part had been erroneous. The method of procedure was this: first, the extent of the drainage area was ascertained; secondly, the amount of rainfall was arrived at by taking an average of a number of years' observations in the neighbourhood; and thirdly, the quantity of rainfall that could be collected into any reservoir which it was practicable to make in the district had to be considered. The capacity of the reservoir should be proportioned to the population to be supplied; and its area was usually about one-twentieth part that of the water-shed. It was almost impossible by means of reservoirs to govern vast floods, and when they occurred an uncertain quantity of water would flow over the waste weirs, and be lost. This loss was usually estimated at 10 per cent., or, with a rainfall of 50 inches, 5 inches. There was also to be deducted the amount lost by evaporation. This, it had been found by experience, might be assessed at 15 inches in this country; so that there could be collected about 30 inches of rainfall. The size of the reservoir to receive and make that quantity available differed in different parts of the country. In Lancashire, where the rainfall was about 48 inches, the reservoir should be capable of storing one hundred and forty days' supply; in Cumberland, where the rainfall amounted to 60 inches, one hundred and twenty days sufficed; but in the eastern parts of England, where the rainfall did not exceed 22 inches, two hundred days' supply should be provided for. As to the amount to be supplied, it was believed that if the waterworks were well managed, and care was taken to prevent waste, 16 gallons per head per diem were sufficient for all sanitary, manufacturing, and domestic purposes; or where the manufactures were in excess, then from 18 to 20 gallons might be allowed. Where the internal fittings, particularly those called sanitary, were not properly looked after, then the waste would cause that amount to be increased from 30 gallons up to 60 gallons per head per diem, and in New York it was reported to be 90 gallons per head per day. The laxity which prevailed as to the internal fittings, leading to this great waste, was alike destructive to the interests of those who supplied the water as well as to those to whom it was supplied; for in many parts of England a scarcity was already beginning to be experienced.

With regard to the particular works under discussion, it was felt that as the rainfall seemed to be less than in England, and the area of the reservoir to be one-fourth that of the water-shed, and as the evaporation from that large surface as well as from the land must, from the statements made in the Paper, nearly approach the whole supply, a want of water was likely soon to arise. There could therefore be little hope of any large quantity of water, adequate to the requirements of the future population, being permanently obtained from the same source. In reference to the fracture of the pipes, 33 inches in diameter, laid through the embankment, it was observed that the same thing had occurred under an embankment, less than 12 feet in height, of a reservoir near Prescot, for the Liverpool water-works.

Fully one-third of the pipes so placed, which were 44 inches diameter, and excellent castings, were broken; and the fractures invariably occurred at the top and bottom. It was remarked that cast-iron in the form of a pipe would stand little external or unequal pressure. If ruptured when in use the water would escape into the embankment, and if it found its way to the back of the puddle the embankment would be torn down and the water in the reservoir be set free. It was not therefore desirable that large pipes should be laid under an embankment where they would be subject to a considerable pressure of earth. It was mentioned incidentally that all plans for conveying the sewage of London through pipes in an embankment, with an unequal pressure of earth upon them, were opposed to experience, and would result in inevitable failure. Then again, the Paper stated that the diameter of the main had been gradually reduced throughout its length from 30 inches at the commencement to 24 inches at the end. For this there was no apparent reason; and although that plan had been adopted in some of the old water-works in England, it had long since been abandoned.

It was observed that when a town was to be supplied with water by surface collection, the first point to be ascertained was the average rainfall over the entire gathering ground, and then the proportion available for storage, which was dependent upon the varying conditions of the rainfall. At Bombay it had been estimated at six-tenths. In the construction of dams for impounding water, it was believed that sufficient attention had not been paid to making them consistent throughout; hence failures arose from their not being watertight. This was to be attributed chiefly to their being raised by the earth being tipped from waggons. At the Edinburgh water-works all waggons were excluded, carts only being allowed, and the banks were formed in layers 6 inches thick, each layer being thoroughly indurated and punned. It was a matter of importance that the best system of constructing dams should be practised, so as to allow of their being made as high as was consistent with safety, as a little extra height added greatly to the capacity of the reservoir. It seemed to be generally admitted that there was great waste in the water supply; for although 20 gallons per head per diem were usually allowed, yet not more than from 5 gallons to 7 gallons per head per diem were used. Opinions were divided as to what became of the difference; whether the loss occurred in the houses or in the mains; but it was thought that the latter was the chief source of waste, and at all events the former could in most cases be checked by the use of meters.

From experiments which have been made with a Dalton's gauge, it was argued that as much as four-fifths of the entire rainfall in this country were lost by evaporation from the surface of the land. This result was corroborated by gauging a neighbouring river, when it was found that the discharge of the river did not much exceed the proportion of rain which percolated through the soil of the gauge.

It was contended that experiments upon a large scale did not show that the amount of evaporation in this country was nearly so high as had been stated; much more rain being impounded year by year than such a statement would lead to the belief. In constructing dams over a loose alluvial bottom it was essential to go below it for a foundation, and with a rocky bottom, seams, fissures, and uprising springs must be especially guarded against. The Holmfirth embankment was said to have been made rotten by a spring in the centre. In one case which was mentioned the springs were collected in a puddled trench, and the water carried into a vertical well of brickwork, rising therein to a level of the adjoining river. It had been a general practice to carry culverts and outlet pipes through the deepest part of embankments; but it was believed that under no circumstances should an outlet pipe be placed in any portion of the 'made' embankment. There should be a vertical shaft or inlet tower, into which the water should be admitted by valves, and the outlet pipe from thence should be made by tunnelling or side cutting in the solid; so that the impounding dam might not be liable to the interference of water.

Allusion was then made to works for conducting and storing water in the east, particularly in India and Asia Minor. It seemed that in many cases the natural springs had been sought out, the water being conducted in earthenware pipes, provided with ventilating shafts, settling wells, wash-out places, and other appliances as perfect as could be devised at this time. The lines of aqueducts for the supply of Constantinople were also described. It was thought that the plan of gathering water, and conveying it through earthenware pipes to a common strong service reservoir was one that might be followed where the springs were tolerably permanent, and in some situations it might be preferable to the use of an impounding reservoir.

Digitized by Google

It was asserted in reference to the enormous waste in the distributing apparatus of towns, that at least two-thirds of the supply to London were lost. Where the supply was regulated by ball-cock the ball was often deliberately unscrewed, and the water run out of the cisterns. Leaky pipes and taps, and especially leaky mains, were likewise the cause of much loss.

With regard to the Melbourne Water-works, it was remarked, that they appeared to be dependent upon the drainage area of 5200 acres. Now, if the statements in the Paper were to be credited, there would seem only to be a rainfall of 6 inches or 7 inches over that area available for the water supply, after deducting the loss by evaporation. This might suffice for 100,000 persons, but as the population of Melbourne was fast increasing, it was almost impossible that a continuous supply could be afforded for many years from this collecting area. It was true that the drainage area of the river Plenty was given as 40,000 acres, which would amply meet the demands of Melbourne for many years to come, but it did not appear that the river had any connexion with the water-works. As to the question of the parallelism of the mains, it was agreed that under certain circumstances, when a main was entirely open as an outlet, and was discharging with its full force, the line of pipes might be tapered. But that was not the condition under which water was sent through pipes for the supply of a town. The pipe was not open at the ends, and the resistance to be overcome was simply that occasioned by the friction of the water moving along the pipe. It was the same throughout, and therefore the parallel figure was the proper one. Towns situated near mountainous districts could not be supplied by streams in a minimum condition, as they were at present appropriated by mill-owners, by bleachers, by paper-makers, by dyers, or by some or all of these trades. This was particularly the case in Lancashire and the West Riding of Yorkshire. If the streams were taken for the water-works, then these parties must still be afforded a regular supply. The reservoirs should be made sufficiently large to equalise all the storms which the country was subject to. Occasionally there might be an excess of downfall, resulting in floods as large as three hundred times the minimum volume, as had been stated; but it must be borne in mind that the minimum volume was about one sixteenth, or even one-twentieth of the mean volume. It had been ascertained, as the result of practice, that generally about one-third of the water utilised was given to the mill-owners and others, and the remaining two-thirds went to supply the inhabitants generally of the town. It had also been found that for a supply of 20 gallons per head per diem reservoirs capable of containing one hundred and forty days' consumption in the north-west of England, and from two hundred to two hundred and twenty days in the north-east of England, were sufficient. Only two instance of complete exhaustion, except where the drainage area was manifestly too small for the population, had been known to take place, and the cause in these cases could be readily explained. They both occurred on the east coast of England: one at Boston, which arose from 40 gallons per head per diem being allowed to be drawn from the reservoir instead of 20 gallons per head per diem; and the other at Newcastle, where the storage was not at the time sufficient, a new drainage area not having come into operation. It had been said that the Liverpool main was too large, not for the amount of water required, which was delivered with the greatest regularity and precision, but because when a pipe of that magnitude burst it usually did a great deal of damage. Repairs were also difficult of execution, the materials being heavy and inconvenient to handle; and if an accident should happen then the supply might be cut off for a day or two. A plan had been submitted to the corporation for two mains, each of 32 inches diameter, instead of one of 44 inches diameter, to be laid 200 yards or 300 yards apart. This it was found would increase the expense by 7000*l.*, and on its being put to the vote, by the corporation, there was a majority of two in favour of one line of pipes.

After the meeting, Mr. SIEMENS (Assoc. Inst. C.E.) exhibited a machine of his invention, manufactured by Messrs. Guest and Chrimes, for joining lead and other pipe, by pressure only. The machine consisted of a strap of wrought-iron in the shape of the letter V, and of three dies, two of which were free to slide upon the inclined planes, while the third was pressed down upon them by means of a screw, passing through a moveable cross-head, embracing the sides of the open trap. The pipes to be joined were placed end to end, and a collar of lead was slipped over them. The collar was then placed between the three dies, and the pressure was applied, by means of a screw-key, until the annular beads or rings projecting from the internal surface of the dies were imbedded into the lead collar. The machine was then removed, and a joint was formed capable of resisting a hydraulic pressure of 1100 feet. The security of the joint was increased by coating the surfaces previously to their being joined with white or red lead. The advantages claimed for this method of joining lead or other pipes over the ordinary plumber's joint were the comparative facility and cheapness of execution, as the cost of a joint of this description was said to be only about one-third or one-fourth that of the plumber's joint. A machine of a similar description was also used for joining telegraph line wires, a specimen of which was likewise exhibited by Mr. Siemens.

April 5.—The first Paper read was, "*On a new system of Axle Boxes, not requiring lubricating, and without liability to heating.*" By ALPHONSE DE BRUSSAUT.

The author first recapitulated the liability to accident arising from inattention to the constant greasing of the ordinary axle-boxes and journals of carriages and of machinery, the inconvenience of accumulating dust and grit on the bearings, and the friction and wear and tear arising from these causes. He then reviewed the numerous inventions and attempts to remedy these evils, showing that none of them had hitherto successfully abolished the necessity for the expensive and uncleanly use of some lubricating matter. He next proceeded to describe the system which he had introduced, and had applied somewhat extensively in France to various classes of machinery in which the use of grease had hitherto been considered indispensable. The new apparatus was described to consist of a series of four, six, eight, or any other convenient number of cylindrical rollers of the length of the journal, retained at certain distances apart from each other, yet still united by elastic bands of vulcanised india-rubber. These rollers, thus united, and placed around the journal, would be set in motion by the pressure of the axle, without the possibility of collision with or friction against each other, or of rubbing upon the surface of the journal or of the bearing, and thus avoiding as much as possible any friction or opposition to the motion of the journal. The action of rolling being thus substituted for sliding, there could not be any abrasion of the substances, and lubricating became unnecessary. The machines so fitted were stated to work with remarkable ease and steadiness, and to be set in motion and the speed to be kept up with considerable facility. No inconvenience had been experienced from the fracture of the elastic bands and shafts, making 450 to 500 revolutions per minute, working perfectly well, without any symptom of heating.

The reasons for this action were stated in a plain and comprehensive manner by showing that in moving a body of an octagonal form along a plane the action must be either by sliding or by rolling; in the former lubrication was necessary, whereas in the latter the presence of any lubricating matter would be prejudicial. Extending the latter principle to the cylindrical form, which was merely a body having an indefinite number of sides, it was evident that by retaining these cylinders apart by means of the elastic bands, so to avoid friction against each other or upon the journal or the bearing surface, a practically perfect rolling motion would be obtained, and it was contended that by M. Brussaut's system the two material results of rapid rotation without heating, and a complete suppression of the use of grease in all journals of machinery were arrived at.

The second paper read was "*On the Permanent Way of the Madras Railway.*" By BRYCE MCMASTER, Assoc. Inst., C.E.

It was remarked that two leading features in the construction of railways in India were, the cheapness of those works entirely dependent upon native labour and the resources of the country, and the expense of those dependent upon England for the supply of materials. Among the latter of these was the permanent way, almost every part of which had as yet to be furnished from England. Thus the portion of the Madras railway from Madras to Arcot, being a length of 65¼ miles, had been constructed for 6000*l.* per mile, of which amount the permanent way alone had cost upwards 3000*l.* per mile. On this portion of the line earthwork for a distance of 25 miles was for a double line, and on the remainder for a single line only. All the bridges and culverts were for a double way. There was only a single line of rails laid throughout.

The permanent way on the portion of the line above indicated, was laid with the double-headed rail, weighing 84 lbs. to the yard, in lengths of 20 feet. The rails were fish-jointed; and six sleepers were used to each rail length. The chairs, wooden trenails, and keys were all of the ordinary construction. West of Arcot the line was laid with rails weighing 65 lb. to the yard. These rails were laid on seven sleepers to the same length of 20 feet. The gauge was 5 ft. 6 in.

The expense of freight from England to Madras, for the first portion of the line was very heavy, owing to all the materials having been sent out during the time of the Russian war. A reduction in these charges, as well as in the weight of the rails, may be expected to diminish the cost of the remaining portion of the line; although the greater distance to which the materials would have to be led, as the work was pushed on into the interior, would add to the cost as the line advanced.

At the commencement of the undertaking tenders were invited in India for the supply of chairs, fishing-plates, bolts, and nuts; but the prices gave no ground for hope that the Indian iron could compete with the English, or that the Indian railways could look for any considerable supply from local sources. But what the country could supply was materials for sleepers, as its forests and jungles afforded a great variety of hard and durable woods well adapted for the purpose. On the Madras railway twenty-eight different kinds of wood had been used; all of which, with few exceptions, had been found to answer well when carefully selected. Although few woods were not attacked by the white ant while lying exposed, and the sap wood in particular was much eaten away, yet in two years after the trains began to run there was not a case known of a sleeper being attacked in the road. The vibration of the passing trains, and the frequent opening out of the ballast by the workmen, seemed suf-

Digitized by Google

ficient to prevent the attacks of this universally destructive insect. Many woods were also liable to the attacks of other insects, which bored holes into them; but the sleepers when covered with ballast appeared to be free from their depredations. Creosoted fir sleepers, sent out from England, were found to be very durable; but their cost at Madras was 8s. 6d. each, or 9s. 6d. each when led fifty miles to the works, while the sleepers procured in the country varied in price from 4s. to 6s. 6d. each. A few thousand half-round Sâl sleepers were kyanised experimentally with corrosive sublimate, at a cost of 6d. per cubic foot; but they were not found to be more durable than those of the same wood when unprepared. In the neighbourhood of Arcot granite blocks were used, but not to any great extent on account of the roughness and rigidity of the road. Near the coast one mile of line was laid with laterite, but the blocks were found to split, and their use was consequently abandoned. Some native-made keys and trenails were used, but the former were not pressed, and although they did very well in wet weather, in the hot season they shrank so much as to be unfit for use. The trenails, which were of teak, answered very well. In laying the road at first the natives were found, as in almost every other kind of work, intelligent and apt when care and patience were taken in their instruction.

The damage to the line from the settlements and slips, from the effects of the monsoons, had been much less than was anticipated, and one monsoon of extraordinary severity having shown all the defects, it was confidently expected that little damage would be done in future; and that the line would be maintained as cheaply as its construction had been inexpensive.

THE INSTITUTION OF FINE ARTS, 316, REGENT STREET.

THE exhibition this year may be pronounced a decided advance upon that of last, though this arises more from its general tone than from individual specialities. This is a fact for congratulation, and one that augurs well, we hope, for the future.

The president, Mr. R. S. Lander, contributes two excellent Scotch pictures: No. 364, "Head of Loch Long," and (397) "Ben Bladach." No. 53 is a large and grand landscape composition, "an October Morning—clearing the ground for winter sowing," by Mr. Peel, who, in (333) "Seeveyholme Leaps, on the Croglin, Cumberland," treats us to another fine piece of English scenery. Mr. Hulme proves himself as delightful a master as ever in the same school: his (80) "in the Meadows, Pyrford, Surrey," and (355) "the Way over the River," are perfect gems of art. Messrs. Herring and Rolfe are fittingly associated in three groups, two of which are farm scenes; one being (105), "the Pet Team"—full of incident; and the other (182), "the Homestead." No. 108, also by the same artists, is named "the Watering-place." Mr. Sidney Percy again lends his valuable aid to the exhibition in three fine pictures: (110) "near Hastings;" (368) a magnificent portrayal of "a Quiet Valley;" and (478) "Passing Shadows." Wild scenery, especially that of hedge and field, has another worthy exponent in Mr. Raven, whose pictures glow with colour and pre-Raphaelite manipulation. Nos. 122 and 126 may be pointed out in illustration of this,—a quality which is preserved also in the other pictures he exhibits.

Passing on in our examination we arrive at a gorgeously finished subject in water-colours (221), a scene from Lucknow,—a figure group,—more truthful, doubtless, than agreeable to look upon. A little farther on is a refreshing little lane scene (232) by Mr. Soper, cleverly touched in; and just beyond, a pleasant couple "Out of Town" (262), and sketching from nature. This latter is by Mr. J. B. Burgess, whose "Hot Chesnut Seller of Spain" (277) is another capital hit. No. 293 shows Mr. Needham's skill in foliage delineation; and No. 331 is devoted to "Beech Wood," which Mr. Leader characterises with praiseworthy skill and patience. No. 306, "Seaside Downs," forms a very good subject for Mr. H. Moore, who also appears to advantage this year in some other pictures. No. 326 is a pathetic scene, "the Last of an Old Comrade,"—two old soldiers are seen watching with saddened thoughts the cutting of an inscription on the tombstone of an old friend: it is painted by Mr. W. Macduff. No. 352 is another subject picture of quite a different kind, in which Mr. Hayllar amusingly indicates, by the mischievousness of a spoilt child, "the Way the Money goes." The Thames, as of old, furnishes an exhaustless theme: No. 372 is one of the many pictures devoted to this subject. No. 398, by Mr. Dell, is a tasteful little bunch of wood flowers. Mr. G. A. Williams presents some very good works, such as (318) "a Mountain Brook," (338) "Repose," and (415) "the Ice-cart," in which the cheerless haziness of a winter atmosphere is very well expressed. No. 457, by Mr. C. J. Lewis, under the title of "Sunday Morning" shows a picturesque old wooden porch to some village church, towards which two children are reverently approaching. One of the most telling landscapes in the collection is No. 459, the work of Mr. E. A. Pettitt, who appears to be a rapid as well as clever artist. In the picture before us, the rich verdure and clear atmosphere of June combine to produce a highly satisfactory bit of colouring, which the artist has felicitously transferred to his canvas. No. 474, "Leading Hay" (A. W. Williams)—a large picture illustrating another every-day scene—is very well given. No. 508 is one of several little cabinet pictures, by Mr. Chaplin, devoted to various kinds of fruit, and charmingly natural.

Among such works as belong more or less to the Pre-Raphaelite school, Mr. Smallfield's will take an honourable position. No. 319 is a larger picture than he ordinarily attempts, but it is throughout very excellently rendered. Showy colours are sufficiently balanced by subdued ones to prevent their becoming too prominent; but striving after excessive contrast seems to be the great aim as well as failing of this school. "Queen for a day" (269), partakes somewhat of this fault, but nevertheless the harmony of colours is very ably maintained. No. 397, "the Popular Song," is a truthful bit of indoor life. Mr. H. S. Marks in (225) gives a highly elaborated pen-and-ink sketch,—subject—"Macbeth's Porter;" and, in (565), gives vent to an irresistibly humorous whim, and calls it "Tooth-ache in the Middle Ages." No. 98 is one of Mr. Rossiter's numerous contributions,—clever, but overlaboured. "Itinerants" (407) is in some respects better; while "Too Hot" (564) is a suitable neighbour to Mr. Marks' "Tooth-ache," just mentioned.

Architectural subjects are here comparatively numerous, but in general do not require much particularising. Two London views by Mr. Sleap (37 and 220) must be pronounced decidedly bad; while another (226), "on the Thames, Millbank," is better. No. 246 "Old Palace Yard," is also pretty good. In (38) Mr. Parrott shews the apse end only of St. Pierre, at Caen; which, though good in its way, is not comparable with the exquisite steeple at the other end. His next picture, "the old Clock Tower, Rouen" (42), is more to our mind, albeit the architecture is none of the purest. Mr. Burnett has two views (43 and 55) at Venice, hardly outlined, and sadly deficient of texture. In the "Ruins at Philæ" (97), he has been more successful. We always welcome Mr. L. J. Wood as a really architectural artist, and though his subjects are generally delineated on too small a scale to convey more than general effects, as much care is taken properly to express the comparative "value" of the several constituent parts. The French edifices which form the subjects of Nos. 93, 94, 95, will be examined with interest. We cannot compliment Mr. Swarbreck's "Interior of the Chapel, Haddon Hall" (156); No. 264, "Remains of Jarrow Abbey," is, however, exceedingly good. This abbey is one of the very earliest architectural ruins in the kingdom. His "Interior of the Lady Chapel, at Rosslyn" (329) is also well shewn. "Teignmouth Castle, Northumberland" (380) is an interior view of the ruins of part of the old priory, now used as a barrack, and a very fine specimen of the "transitional" period of architecture. No. 404 is the last of this artist's contributions, and a worthy pendant to (264). In No. 214, Mr. Rudge has a distant view of that lovely ruin Tintern Abbey: No. 219 is Holyrood Abbey, by Mr. E. Sharpe. No. 286 is a highly interesting picture, by Mr. Gray, of "the Cottage, South Wingfield Manor House, Derbyshire," of which every part is carefully detailed. Nos. 241 and 244 are by Mr. Ernest George: in the former the fine Norman arches in Minster Church, near Ramsgate, are very correctly drawn. The church is altogether one of unusual interest to both antiquarian and architect. Mr. Henshall has two architectural pictures; one (287) shews "part of the Church of St. Jaques, Dieppe," and the other (402), Rouen, from the banks of the Seine. The odd grouping of the buildings in this picture is very noticeable, but there is a monotony about the whole which mars the effect. No. 300, "Evening, at Antwerp" is a pretty distant view of the town, by Mr. H. Williams; it appears however to lack power in the treatment of the foreground. No. 322 "Fetcham Church, Surrey" (G. B. Moore), with its ivy-mantled tower, forms a pretty picture, somewhat we think, out in the perspective; while Mr. Clark's "Dunsfold Church" (373), in the same county, will convey an idea of the exterior of one of the simplest and prettiest rural churches in England. It is throughout of Decorated date; and, owing possibly to its secluded position, has fortunately hitherto escaped any questionable improvement.

Digitized by Google

REVIEWS.

On Some of the Grounds of Dissatisfaction with Modern Gothic Architecture. A Lecture delivered at the Royal Institution of Great Britain. By EDMUND BECKETT DENISON, M.A., Q.C. London: J. H. and J. Parker. 1859.

Mr. Denison, though by profession linked to another pursuit, is, it need scarcely be remarked, enthusiastically devoted to architecture, especially as it is developed in our own mediæval examples. With these he has to a great extent made himself personally acquainted, and that not in a *dilettanti* sense merely, but historically and analytically. Hence whatever opinions he may venture to propound in connection with Gothic architecture, are sure to carry with them some weight, and to furnish at least materials for deliberation, though that may not always result in acquiescence. The form of *lecture* is the one which he has almost uniformly chosen for his purpose, and it must be allowed to be the best means of popularising the subject, which appears to be Mr. Denison's chief aim. Certain it is, that he is well qualified for such *vivâ voce* proceedings, his addresses being delivered from notes only: hence the apologies we meet with on their publication, that the author has used these notes only as an outline to be filled up, inasmuch as he does not profess to remember accurately what he said.

In the case before us we have a pamphlet of upwards of thirty closely printed pages, containing "a fuller version of the lecture than the usual abstract," and it of course has the advantage of being deliberately penned, and therefore it may be presumed, expresses in the most suitable terms the author's real views. Not by any means an insignificant portion of the address is occupied with purely self-laudatory remarks, which, even supposing them to be in good taste, particularly on such an occasion, are little more than egotisms which have been already printed over and over again. Who does not know that over the new parish church at Doncaster it was Mr. Denison's "lot to exercise an unusual amount of superintendence," and over its neighbour, St. James', which was completed at the same time, "something more than superintendence?" Yet a repetition and amplification of these assertions consitute a large portion of the bulk of this essay; and in other parts the writer goes over the same ground as in his "Lectures on Churchbuilding," which in a former number (April, 1856) we reviewed and quoted from at length, so that the portion which relates to the immediate subject is found to be included in a comparatively small compass. We believe that since Mr Denison's strong and weak points are by this time pretty well known, our readers will prefer hearing what he has to say as much as possible without note or comment, and will themselves perceive where to take it *cum grano salis*, and where to indorse it in its entirety.

By a curious coincidence the House of Commons was engaged on the identical evening when this lecture was delivered, in discussing almost the same theme in connection with the New Government Offices, and this circumstance furnishes Mr. Denison with the subject of his preamble, and which he has turned to account very dexterously.

"One would almost fancy that we were put back a couple of centuries, and listening again to the kind of description which used to be given of the Gothic style by the leaders of the public taste in the days of the Restoration, when all Gothic art was supposed to be dead and buried far too deep for any chance of revival. This is the character which the once celebrated John Evelyn, who was one of the commissioners for rebuilding St. Paul's cathedral, gave in his treatise *On Architecture and Architects* to the style of all the great cathedrals of the world except his own and its prototype at Rome. He calls it 'a certain fantastical and licentious manner of building, introduced by the Goths and Vandals and other barbarous nations, who demolished the glorious Roman empire with its stately and pompous monuments, and filled not Europe only, but Asia and Africa also, with mountains of stone, vast and gigantic buildings indeed, but not worthy of the name of architecture, congestions of dark, heavy, melancholy, and monkish piles, [Lord Palmerston's view of Gothic almost verbatim] without any just proportion, use, or beauty, compared with the truly antient; so as, when we meet with the greatest industry and expensive carving, full of fret and lamentable imagery, sparing neither of pains nor cost, a judicious spectator is rather distracted or quite confounded than touched with that admiration which results from the true and just sympathy, regular proportions, union, and disposition, and from the great and noble manner in which the august and glorious fabrics of the antients were executed;' with more nonsense of the same kind, to which other similar nonsense from other writers of the two last centuries might easily be added.

* * * * *

"I do not mean to 'prove' anything that I am going to say, or to give any reasons for it, except that I have arrived at certain conclusions or opinions from experience and observation, which you can verify for yourselves. I do not mean even to claim the merit of novelty for them. Most of them have been in substance published before, both by myself and by others. But what I have to say about them is, that within the last few months two buildings have been completed [St. George's and St. James' churches, Doncaster], in which these conclusions, or theories, or whatever you please to call them, have been enforced in practice for the first time, I believe, since the fall of Gothic architecture 400 years ago.

"I believe it is no exaggeration to say, that St. George's is universally considered the finest Gothic building of modern times; and as far as its pretensions go, the other is pronounced by most people who have seen it, to be fully equal, and in some respects superior, even to its more magnificent neighbour. Nobody is more sensible than I am of the faults in each of them, notwithstandiug their general success; but there is no building of any age without some faults quite as striking; and whether that be so or not, the conclusions which I have arrived at respecting the common cause of dissatisfaction with modern Gothic building are founded no less upon the defects than upon the beauties which are apparent in these two buildings.

"The first cause which I shall notice is one which few persons can have failed to hear alleged as an excuse for the inferiority of modern to ancient architecture in every style; and that cause is stinginess. But with the exception of a certain class of buildings which I will advert to presently, I believe it would be nearer the truth to say that so far from stinginess accounting for the general failure of modern architecture, there never was a time in the world when money was spent on building in such profusion.

* * * * *

"No doubt in the best Gothic times it was the case that the more elaborate a building was, the handsomer it generally was; and so it ought to be in all times. But so far is it from being so now, that I should almost be inclined to say, that if you wish to make quite certain of a failure in the most essential elements of good building, you had better give out at once that you do not care how much you spend. No doubt that looks like a paradox, and it is not a complimentary one to the present race of architects; nevertheless, I adopt it, not from theory, but from observation, and I believe that if you will use your own observation you will come to much the same conclusion. If it is necessary to account for such a phenomenon, I should attribute it mainly to the existence of one of the most mischievous delusions ever propagated on this subject—that '*ornamentation is the principal part of architecture.*'.....Mind, I am not saying anything so absurd as that arcitecture is not improved by suitable decoration; but I say that, as a bare matter of fact, a great deal of what is universally admired as architecture of a very high order, much finer than the most highly decorated modern building, is almost or altogether independent of both carving and colouring.

* * * * *

"I do not know whether it is owing to the latent or avowed belief in this theory that decoration should be aimed at first and principally, before instead of after all the other conditions of grand building are satisfied, or to pure and simple ignorance and incapacity for observation, that there are hardly any modern buildings which are not deficient in two primary elements of all grand building in any style whatever: I mean massiveness, and depth of shadow, which is the visible evidence of massiveness, besides having a beauty of its own.....The same fault is generally noticeable in the woodwork as in the stone of modern buildings; frequently, and with some architects invariably, it is even worse.....The old builders, who knew how to build stone roofs and wooden roofs, which are stronger now after five centuries than many that were built last year, knew very well that they were using more materials than were requisite for merely satisfying the mechanical conditions. But they knew also that engineering is not architecture, and that science is not art, though it is involved in it, at least in the art of Gothic building, the architecture of pointed arches, and vaults, and buttresses, of open roofs, and tall spires; and why should we not add of domes,—not the low and clumsy Roman or Byzantine dome, incapable of standing on its own base, but the truly scientific and beautiful Indian or Saracenic pointed dome, chiefly built I suppose in horizontal courses, and therefore capable of standing alone, and presenting an outline like a tall Gothic arch standing on its piers, and with a more than Gothic independence of abutment beyond them!

* * * * *

"The next common modern mistake which I have to notice, is another instance of a truth turned into falsehood by exaggerations. You have all heard or seen how St. Peter's at Rome fails, from the magnitude of all its parts and details, in producing the proper impression of its size, and you will see in Mr. Fergusson's and Mr. Garbett's books some strong observations on and illustrations of the same want of subdivision of even the Gothic cathedrals on the continent, into parts of moderate size with a distinct outline to each—an art which was far better understood by the English architects, who knew how to give to our cathedrals an appearance of almost unlimited extent, though they are generally smaller than the foreign ones. Well, all this is perfectly true and right, and it is undoubtedly an architectural blunder to have great size and yet not to get the full effect out of it. But the modern architect interprets this truth to

Digitized by Google

mean, that if you only make plenty of distinct parts in a building or a window, of any size, and put plenty of stages in a buttress, or mouldings in an arch, the eye will be cheated into believing that the building is large, the window a grand one, the buttress high and deep, and the wall thick: precisely the reverse of all which is the fact. The eye is not such a fool: though its owner may not be wise enough to know how he has discovered the cheat, yet he always does discover it—and more; for by a strange but just retribution, buildings designed on this fraudulent principle generally look even smaller than they are; and for this reason: the eye soon perceives that everything within its power of measuring is small and paltry, and therefore the mind instinctively concludes that the whole is, whether it is in fact or not. Of the two mistakes, the old foreign one is immeasurably the best; inasmuch as it is far better that you should find a building to be greater than you thought at first, instead of gradually discovering that the more you see of it the more paltry and mean and good for nothing it is: not that buildings are the only things of which this is true.....I have already alluded to the modern passion for the foreign characteristic of height, and the disposition to sacrifice to it the more English and certainly more useful one of length. I should say of height, as of ornamentation, of course it is a valuable element of architectural effect, but it ought to come last, not first; and I will add, as my own opinion, that it ought very seldom indeed to be the leading characteristic of a large building; for when it is, it is extremely likely to destroy that character which everybody understands by the term Repose, and for which our own long cathedrals seem distinguished above all others in the world. Some of them are undoubtedly too low; but too low for their breadth, not their length; and with our usual discrimination and good taste, breadth is the dimension into which we almost invariably expand now when size is wanted; and thus the length is doubly overpowered..... A still worse fault of the same family is the passion for building high spires on bases about half as wide as the old ones. This vile practice seems to me to concentrate all the bad taste, and pretension, and ignorance of proportion, which will be recorded some day as the characteristic of this age. The architects profess to be reviving the architecture of the thirteenth or fourteenth centuries—'taking that as their starting point' for further development; and yet they seem to have discovered that the builders of Salisbury, and Norwich, and Grantham, and Coventry, and Louth, and Newark, and Lincoln, and Ely, and old Doncaster, and all the towers of the West, knew nothing of their business, and of the proper width for a tower in proportion to its height..

* * * * *

"There is only one more physical cause of the general failure of modern Gothic architecture which I mean to speak of. And on this one I am glad to say that I can agree with Mr. Ruskin as thoroughly as I differ from him about some others, especially his ornamentation theories. The thing I refer to now however is no theory, but a simple matter of observation so plain and obvious that there is very little to say about it, except to desire people to pay no attention to theories of perfect building, but to use their eyes; which, however, is generally the last thing we learn to do. Now everybody who does condescend to learn in that way, will see, the first time he really looks at any old Gothic building in good preservation, and at any new one, that the old one is, as a builder would say, shockingly inferior in the execution of the work. He will see no kind of precision about the joints anywhere; no edge, or *arris* (as the builders call it), is either quite a straight line if it professes to be generally straight, or quite a regular curve if it is curved.....In short, you will see what will strike you as a general carelessness about execution; and usually the inequalities are greater in large work, heavy mouldings, and bold carvings, than in small; or, as Mr. Ruskin well expresses it, 'the execution is always subordinate to the design.' Whereas, the pride of modern work is precision and *finish*, as the masons and clerks of the works will tell you themselves, and probably call your attention to the excellence of their performance in that way, if you give them a chance."

The following is a suggestive paragraph, and it will be seen to bear out our remarks with regard to the author—

"I have described in the book before referred to how I accidentally learnt that 'finishing' is really spoiling, by finding a moulding lying about which seemed to me exactly right, and like an old one, and being told by the man whom I asked how it came to be so, that 'it was not finished.' I have not time to dwell further on this point now, beyond saying that with extreme difficulty, and in spite of resistance which required a very strong hand to put it down, I succeeded in getting most of the work at Doncaster left 'unfinished;' but in that respect also there is just enough done in the usual way to enable anybody to judge of the difference, for the joints of the nave pillars were pointed up as usual, and present their white lines like a band of paint at every joint, and the inside stone work was scraped; whereas the great pillars were not allowed to be touched after they were built, nor any of the outside work or window tracery. At St. James's nothing of the kind was allowed.

* * * * *

"I believe the progress of Gothic architecture, rapid as it has been, would have been more rapid, and at any rate more complete as it went on, but for the impatience which is one of the characteristics of these times. I do not mean merely that kind of impatience which is evinced by those who told the Gothic architects only eighteen years ago, that they must 'be content to lay the foundations of an edifice which future generations shall see completed, and to toil for the recovery of hidden principles and lost harmonies which the master spirit of a succeeding age may awaken into life;' and then, within less than half the time of a single generation, turn round upon the men who have been so toiling, and declare that they can wait no longer; and that they are now convinced that some unknown and scarcely imagined compound of the Classical and Gothic styles is the thing to toil after and harmonize. This particular phase of impatience may not be common, but when we think of the variety of architectural fashions which have now flourished within less time than was occupied by the shortest-lived of all the old Gothic styles, we must come to the conclusion that our architects are either much cleverer than the old ones, or else much more impatient."

The following opens up a much controverted question:—

"A few years ago came in the marble and colour mania, imported principally by Mr. Ruskin from Venice; a magnificent discovery for the architects, but not so certainly for architecture just at present; for the apparently inevitable effect of a rage for colour seems to be that it makes people more careless about form than ever; and no one I think will say that the knowledge of architectural form and proportion is in such a highly advanced state that we can afford to let it take its chance for a few years while we are speculating in some other element of beauty. I am far from objecting to the introduction of marble shafts, or granite pillars, wherever people like to pay for them: but if they fancy that a building otherwise bad, feeble, and in short, ungothic, will be made into a good one, capable of giving lasting satisfaction or pleasure, by putting in a certain quantity of marble instead of stone, they will be mistaken, and will find that the choir of Selby, and the nave of St. Alban's, and fifty other whitewashed churches, are still perversely admired, while all their beautiful colours are despised. *A fortiori*, the same is true of painting; for marble being composed by nature is sure not to be bad in itself, whereas painting has an unlimited capacity for badness in itself, and unfitness for its place besides."

* * * * *

"I am not sure that I know what that imposing, but only plagiarised phrase, 'the architecture of the future' means; and even those who are fondest of using such pieces of cant magniloquence have not always a very distinct apprehension of their own meaning; but I am tolerably certain that if it means a style of architecture which is to last as long as the shortest of the old styles, or to have any chance of being treated with respect, or looked at with satisfaction when the future has become the past, as all the genuine styles of old still are, it must be something very different from what is contemplated by our present seers. Vitruvius, the great authority on the classical styles, is quoted by Evelyn as saying that among the twelve things which an architect ought to know is astrology. I wonder from what signs it is divined that a new architecture, to be celebrated in future ages as the Victorian style (for so it has been already christened by persons who are too impatient even to postpone that ceremony till the usual time), is so near the ascendant now. I cannot help thinking that we are more likely to glide into a new style (if there is ever to be one again deserving the name) by learning first to stand a little more firmly on the old ground, from which most people now agree that we must take our start, before we are in such a hurry to take it. If the new style is to be a composite one, it is not very likely to be developed except by men who show by their works that they are thoroughly master of the others from which it is to be compounded. We are a little too ready to assume that a knowledge of dates and facts and measures, and all the history of architecture, (which is probably greater now than ever,) is a proof of a practical mastery of principles; but knowledge is not necessarily power, in spite of competitive examinations."

"The last cause of dissatisfaction with modern Gothic building which I have to notice is of just the opposite kind to that of impatient running after novelties, whether 'antiquated novelties,' or novelties of invention, which I have been complaining of just now. It is too often forgotten that architecture is not archæology, nor ecclesiology either; and many foolish things are set down to the credit or discredit of Gothic architecture, which it has nothing in the world to do with, except that somebody has chosen to embody his own antiquarian or ecclesiastical fancies in a Gothic building. I fully appreciate the obligations of Gothic architecture to the archæologists, who saved many a fine building from being burnt into mortar like the greater part of that most beautiful of ruins, St. Mary's Abbey, at York, at a time when almost everybody thought, as Lord Palmerston and his adherents still do, that Gothic architecture was a relic of barbarism. And the modern advance of architecture in the only style which has advanced is undoubtedly due in a great degree to the ecclesiologists. But for all that we cannot afford to let either of them be our masters. Architecture is the art of erecting new buildings for use and beauty; even Mr. Ruskin, with all his love of decoration, puts use and fitness for its purpose as the first condition to be satisfied by a building, though of course not the only one. Archæology (so far as it relates to our business) deals with the preserving of old buildings; a very good, but a very different thing; and ecclesiology is obviously more different still; and at any rate it has nothing to do with civil architecture, about which the fight happens to be just now; for our opponents say that we have carried the ecclesiastical and eleemosynary

Digitized by Google

position, even the Protestant Dissenters having now joined us in it; the Romanists alone seem to be discovering that the architecture of Rome after all suits their purposes the best, and it is remarkable that their modern Gothic buildings are seldom among the best specimens; there are many better dissenting chapels.

"I think therefore that everybody who feels interested in the progress of architecture ought to resist all attempts to overwhelm and choke it by either ecclesiastical or antiquarian pedantry."

The Literary and Educational Year Book for 1859.
London: Kent & Co.

The multiplicity of books of a similar nature to that mentioned above is a proof of their usefulness and ready sale. Indeed, no class of work is so welcome on a library table as a compendious book of reference, one which just answers the purpose of assisting the memory, or giving current information on a variety of subjects in the fewest possible words. The volume now before us presents an aggregate of statistical and other items such as we feel assured have rarely if ever been before collected. Some of the titles are worth enumerating, as they will serve to explain the peculiar recommendations of this 'Year Book.' There is a list of important works published during the past twelvemonth,—a list of new editions of standard works,—of American and foreign books generally;—titles of papers in the quarterly reviews;—new maps and engravings;—newspapers, English and foreign;—metropolitan periodicals and publishers;—a variety of information relative to our universities and the several colleges and schools in the kingdom;—also lists of members of the different learned, scientific, and artistic societies of the metropolis, with a summary of their proceedings, &c. &c. Some excellent hints are given too on the formation of mechanics' institutes, and itinerary libraries, and an abstract of the law of copyright in different countries,—the whole comprised in a half-crown volume, the size of an ordinary quarterly review. It may be imagined that, as this is the first volume that has been issued, it will be found not altogether perfect. This is modestly apologised for in the preface, and the editor requests that, to render it more perfect in future, any corrections or additional information will be supplied by "lecturers, editors, secretaries of public societies, the proprietors or teachers of grammar and other first-class schools. For our own part, in dipping pretty freely into its contents, we have been astonished at its general accuracy and fullness: the principal drawback being that the latest particulars have not been in every case ascertained; and, this being so essential a point, the conductors will do well to pay it special attention in forthcoming volumes.

RAILWAY CHAIR AND FASTENINGS.

Robt. H. Bow, C.E., *Patentee, Edinburgh.*

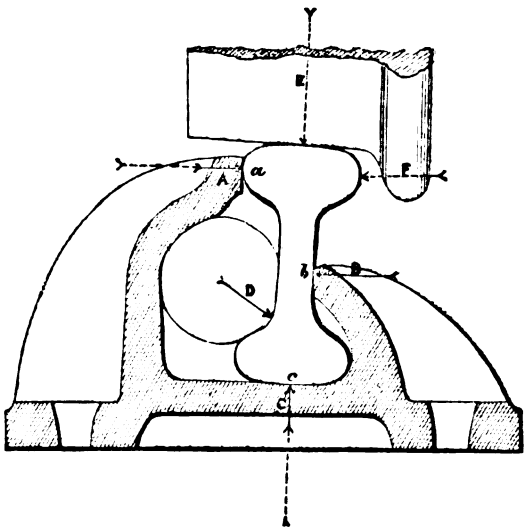
The mode of action of this chair is as follows:—The rail is maintained in its proper position by being made to bear against the three resisting points or surfaces of the chair *a*, *b*, and *c*. The pressures which the rail exerts against these points are brought into play by a fourth pressure D, arising from the action of a key, wedge, screw, or other fastener.

The pressure D, from the key, wedge, or screw, becomes resolved into a vertical pressure C, which serves to hold the rail down in the chair, and into a horizontal pressure, which is balanced by that at *a* acting round the point *b* as a fulcrum.

The additional pressures to which the rail may be subjected by the action of the wheel, may approximately be represented by the dotted lines E and F. But these can only augment the previously existing two pressures C and A, as indicated in the figure, so that the compression of the wedge or other fastener is of a constant character, and need be of but small amount compared with that which the key in the common chair has to withstand.

The chair at present in most general use is objectionable, in making the steady motion and safety of the train depend too much upon the presence and condition of the wooden key. The key in it is absolutely necessary for the maintenance of the rail in an erect position against the action of the flange of the wheel. Many chairs are so designed that they require the inner jaw to fit the lower shoulder of the rail with great accuracy, in order that the rail may be held steadily down in the chair; and when, in the course of time, the top of the rail becomes worn out, and the rail turned, the chair can no longer keep the rail down in its seat; such a misfit could not but lead to much injury being done both to rolling stock and permanent way, as, whenever a train passed rapidly along, severe blows would be interchanged between rail and chair.

The patentee states that in this chair the rail withstands the pressures from the wheel without the aid of the key; the actual use of the key in it being to keep the rail constantly pressed against its bearings *a*, *b*, and *c*, so as to prevent any rattle from vibration. And no serious evil could arise from the absence even of several adjacent keys, since the general action of the pressures from the wheels could not upset or bend the rail, as would be the case with the common chair.



In the common arrangement the key soon becomes loose from the alternating wet and dry condition of the wood; and from the occasional blows and severe compressions to which it is subjected. The first of these causes is got rid of by using keys thoroughly saturated with creosote; the second remains in the common chair, but does not exist in the form herein described. The usual frequent inspection and adjustment of the keys is thus rendered unnecessary.

When necessary to invert the rail in this chair, it would fit equally well in its new position; it would sit a little lower, but this would not affect its inclination or steadiness, and the height of the outer jaw of the chair is originally made so low as to keep it well out of the way of the wheels. These advantages are not gained by the sacrifice of any good property of the old chair; the rail can still be dropped in from above; the key is still on the outside; and simplicity and cheapness are still leading characteristics.

When used as a joint-chair, the new form possesses the following advantage:—In the common joint-chair, the meeting ends of the rails may get out of line; horizontally by one end working further into the soft substance of the key than the other, and vertically from bad fitting of the inner jaw. In this chair the ends of the rails are held in perfect line, by each being pressed against the common bearing surfaces *a* and *c*.

When the employment of a wooden key is objected to, as for use in India, the pressure D may be produced by means of an iron key, wedge, or screw. When a screw is used it may be tapped through the jaw of the chair, and bear against a bent piece of steel, 3 or 4 inches long; or it may work through a nut let into the chair, and bedded on an elastic washer. In this description of the chair its application to rails of the most frequently used shape has alone been considered; but the same method of fastening the rail is applicable to many other forms of section.

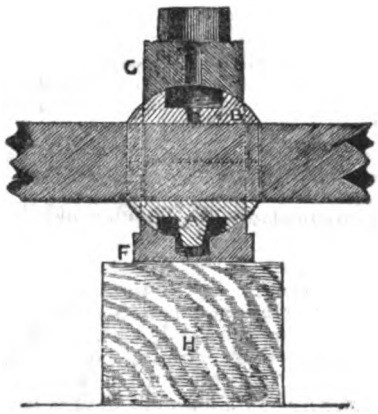
SELF-ADJUSTING SPHERICAL BEARING.

The Spherical Self-Adjusting Bearing shown in the accompanying illustrations has been patented by Messrs. Wallis and Haslam, engineers, Basingstoke. It is composed of four parts,—the seat or block, the upper and lower brass, and the cap. Fig. 1 is a cross section, and fig. 2 a sectional elevation. The seat or block F, and the cap G, are turned internally in such a manner, that when put together their interior surfaces form a spherical cavity, with a portion removed on each side of the block, leaving

Digitized by Google

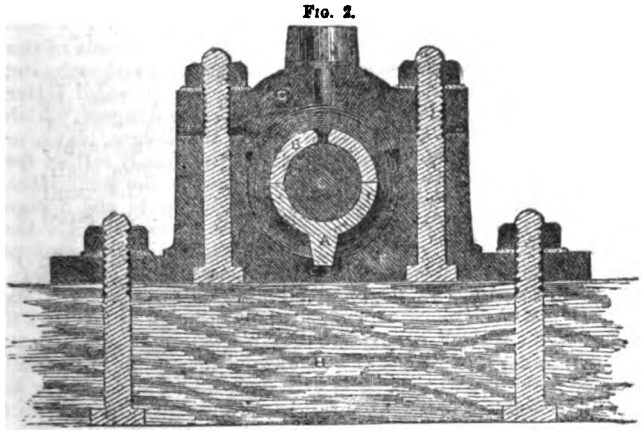
openings through which the shaft or spindle passes out, surrounded by the brasses in which it revolves; and the upper and lower brass B and A, after being bored in the usual manner for the reception of the shaft, are turned externally to the form of a sphere of the same diameter as the cavity in the block, so that on their being placed in the said cavity, and the cap adjusted over them in its place, they form a universal joint, which will turn freely in any direction within certain limits. On the under side

Fig. 1.



of the lower brass A, is cast a nipple, which descends into a socket E, bored in the bottom of the block to receive it. This socket is considerably larger than the nipple, and will therefore

Fig. 2.



allow sufficient motion for the brasses to adjust themselves to the position of the shaft, while, at the same time, it prevents their rotating along with it, which they might otherwise be liable to do. The brasses, as shown in the engravings, are lightened in weight by having a channel cast round them at right angles to the shaft, which does not, however, interfere with their self-adjusting properties. They are also constructed with a short lengthening portion, or nose, at each end of the brasses, for collared journals, or in cases where unusual steadiness is required. The part claimed by the patentees is the application of the ball and socket joint to shaft or axle bearings of any description. These bearings may be applied with advantage to railway carriage axles, as their self-adjusting properties will allow the wheel to rise or fall with the inequalities of the rail without in the least affecting the relative position of the axle journal and the brass in which it revolves. They are also particularly useful in cases where shafts or spindles run at a high speed, or from any cause are liable to heat or wear crossways in the bearings, as they instantly adjust themselves to the slightest variation in the line of direction of the shaft, while at the same time they are quite as steady in work as the ordinary description of bearings.

The three successful competitors in the Manchester Assize Courts competition are—first, Mr. Alfred Waterhouse, Manchester; second, Mr. Thomas Allom, London; and third, Mr John Robinson, London, to whom the premiums of £250, £150, and £100 respectively have been awarded.

OUR METROPOLITAN RAILWAY BRIDGES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Railways are a great necessity of the times, but art-progress also is usually and truly considered an attribute of the age, which now indorses the idea that useful things can possess beauty as well as utility. Looking at it in this way, one is at a loss to understand how it has come to pass that the ugly railway arches we see crossing our great public streets have been allowed to be erected, and our eyes and taste offended by the bald and inelegant structures reared across our paths; this offence against good taste being by no means a matter of necessity, for these arches or viaducts might with a very moderate outlay have been—indeed, might yet be—rendered an ornament to the streets. Such an arch as that which crosses the Westminster Bridge-road might have been Gothicised and rendered ornamental by panelling the parapet of the bridge, making the spandrels of ornamental character and finishing them off with ornamental corbels. In some cases it would be a great convenience if an additional ornamental parapet were provided outside the railway parapet, for foot-passengers to cross the thoroughfare, reached by light iron staircases.

Doubtless the railway companies will say that they ought not to have this additional expense thrown upon them, but I think the Londoners have the right to reply, that whilst these companies can afford to build elegant and expensive stations at places of much less importance than this metropolis, and erect ornamental bridges in remote corners of private parks for the possible delectation of the owner, the railway bridges or viaducts crossing main streets of a great town should be designed with the view to produce an agreeable architectural effect, as well as answer all the required useful purposes.

Now that we have several metropolitan railway projects on the *tapis*, it is worthy of consideration whether something could not be done in this matter; and it is to be hoped that the Metropolitan Board and all whom it may concern will take order herein.

MEGALOPOLIS.

SUPERHEATED STEAM.*

THE idea of working engines by superheated steam, and the immense saving of fuel and increase of power it would effect, was, we believe, first started many years ago by Mr. Howard, and subsequently by Dr. Haycraft. At a later period the matter was again taken up by an American enginer (Mr. Wetherhead) who, however, only superheated a portion of the steam and mixed it with common steam in its way to the cylinders. The success which attended even this partial application of the process again revived the idea and encouraged other engineers to turn their attention to the subject. The result of these renewed efforts is, that several methods of securing the great economy to be effected by superheating the steam are now under trial.

As to the various proposed methods of superheating steam, it may be briefly explained that the conditions required to be fulfilled are perfect simplicity of arrangement with ready control over the apparatus; that it should be so placed as not to be liable to accidental injury in the engine-room; and that the heat employed for superheating the steam should be waste heat, which has already done its duty in the boilers and is passing away. All these conditions have been most satisfactorily fulfilled by Mr. Penn in the new engines on board the Valetta. The Valetta was for many years the mail-boat between Marseilles, Malta, and Constantinople. While thus employed she had Penn's engines of 400 horse-power.

Mr. Penn, at the repeated request of Mr. Allen, the managing director of the Peninsular and Oriental Company, undertook to apply to them the principle of superheating, to which his attention had many years before been seriously directed by Dr. Haycraft. His method of doing this is to place in the smoke-box of the boiler, through which the hot air from the furnace first passes, as large a number of small pipes as is consistent with allowing a free draught from the furnaces, Through these all the steam from the boilers passes in its way to the cylinders. By this plan an immense heating surface in the pipes is secured, the steam is in a subdivided form, so as to be readily acted on, and the waste heat from the furnace is utilised at the point where

* Abridged from the *Times*. For account of previous experiments with superheated steam, see proceedings of British Association, *ante*, vol. xxi. page 365.

Digitized by Google

its intensity is greatest, and where the greatest conveniences exist for applying the apparatus. By the means of three ordinary stop-valves the whole contrivance can be shut in or off from the engines at pleasure. In ordinary engines steam leaves the boilers at about 250°, but declines from this temperature in its way to the engines to 230°, undergoing from condensation a still greater and more serious diminution of heat in the cylinders. From these causes, and also from the immense quantity of waste heat which escapes through the smoke-box and up the funnels, there has always been a theoretical loss of steam power amounting to 40 per cent. as compared with the coal consumed. It is this loss of power and waste of heat which the superheating process is intended to prevent, and which will allow a reduction of from 28 to 30 per cent. on the fuel now consumed. By the superheating process the steam is raised in passing along the pipes in the smoke-box (where the heat is about 650°) from a temperature of 250° to 350°, and so enters the cylinders at 100° in excess of the temperature due to its pressure. This extra heat is, of course, rapidly communicated to the metals, and prevents the condensation in the cylinders or other parts of the engines which would otherwise, of course, take place. A smaller amount of cold water is required to condense the steam at this high temperature of 350° than when at the ordinary heat of common steam.

At the measured mile at the Lower Hope, near the Nore, the result of repeated runs gave an average speed of nearly 14½ knots per hour, thus realising with engines of 260 horse-power, and a small consumption of fuel, the same rate of speed as had been gained with her previous engines of 400 horse-power, and a consumption of 75 tons of coals per day. The superheating apparatus evidently effected a most important saving in fuel, but until an average of many days' working can be obtained, it would be difficult to estimate the exact amount economised. The thermometer during the trial indicated in the steam pipes an addition to the ordinary temperature of 100°, which Mr. Penn believes to be enough for all practical purposes of superheating. Even when making from 33 to 34 revolutions per minute, and driving the vessel against a strong head wind and tide, it was impossible to consume all the steam generated, which was blowing off from both boilers all the trip.

THE ARCHITECTURAL MUSEUM.

(SOUTH KENSINGTON MUSEUM).

Prizes to Art-Students and Artist-Workmen, 1859.

Prizes for Wood Carving.—The Committee of the Architectural Museum offer to Artist-Workmen two Prizes of £5 5*s.* and £3 3*s.*, as First and Second Prizes, for the most meritorious specimens of carving in Wood, being the enrichment of a hollow moulding, not less than 18 inches long and 7 inches wide, either in naturally or conventionally rendered foliage, with or without animal life. The work may be executed in either hard or soft wood as the workman pleases.

Prizes for Coloured Decoration.—A Prize of Five Guineas is offered by the Committee of the Ecclesiological Society (of London), through the Committee of the Architectural Museum, for the competitor who shall show himself most successful in Colouring, according to his own judgment, a cast from a panel (one of eight) from the side of a tomb in the Church of San Giovanni, Verona. It contains a draped female figure, surrounded with foliage on a flat ground in low relief, and inclosed in a narrow border. Mr. Beresford-Hope, M.P., will give Three Guineas in one or more extra prizes if any works appear deserving of being so rewarded. This being specifically a colour prize, the same cast for competitive coloration is proposed to all the competitors. The candidate may adopt that medium for applying his colours which he prefers, but he is expected to treat the panel as forming a portion of an architectural composition, and not as a cabinet piece. The original is in marble.

Casts from this panel will be supplied on application to the honorary secretary of the Architectural Museum at 5*s.* each at the Museum, or by payment of 2*s.* extra for packing and case. Duplicate casts will be allowed. The Committee of the Ecclesiological Society will themselves adjudicate.

General Conditions.—All specimens sent in competition for the prizes must be deposited in the Architectural Museum, free of cost, by the 1st of December, 1859, with the competitor's name and address, and those of his employer (if any) attached. They will remain the property of the competitor or his employer, and will be exhibited in the Architectural Museum for one month before the prizes are awarded, and also until after the day of presentation if thought desirable. The specimens must be removed at the expense of the respective competitors. The prizes will not be awarded unless there appear sufficient merit in any of the specimens to entitle them to such distinction: but certificates of merit, in addition to the prizes, will be given in such cases as the judges may consider deserving.

GEO. GILBERT SCOTT, A.R.A., Treasurer.
March, 1859. JOSEPH CLARKE, F.S.A., Hon. Sec.

(13, Stratford-place, W., where communications should be addressed.)

Patent Law for India.—The law granting patent rights in the Indian territories having passed the legislative council in India, has received the assent of the crown, but has not yet been promulgated in India. By it British patentees will be enabled to obtain patent rights in that country, provided they make the proper application within twelve months from the date of the British patent.

The National Wallace Monument.—The acting secretary of the Wallace committee, Dr. Rogers, of Stirling, has recently issued details for the guidance of architects intending to compete, from which we obtain the following particulars:—The monument is to be erected on the Abbey Craig, near Stirling. The Abbey Craig, is situated in the midst of a level plain, bounded by ranges of hills at various distances. In the directions of east, south and west, the Craig may be seen at a distance of twenty miles. From the site of the proposed Monument are seen the battlefields of Stirling Bridge, Bannockburn, Sauchieburn, Falkirk, and the district of Sheriffmuir. The funds for the monument at the disposal of the committee are £4000, but designs may be prepared which would cost £1000 more. There are three excellent quarries in the vicinity, one of trap or greenstone at the Craig's north-eastern base; a second at Bridge-of-Allan, in the old red sandstone, one mile distant; and a third of pure white freestone, at Bannockburn, at the distance of four miles. There is a railway station at Causewayhead, within a few hundred yards of the Craig. Designs, plans, or models, and specifications, with estimate, must be sent in by the 1st of June next, with a sealed letter bearing a motto and the name and address of the designer, which letter will be opened only in the event of the designs, plans, or models bearing the corresponding motto being finally settled for adoption, premium, or honourable mention by the committee. In the event of the committee giving a preference to any design which it may be afterwards found cannot be carried out for the estimate given, it shall not be obligatory on the committee to adopt it. The plans and elevations to be drawn on a scale of 2 in. to 10 ft., and be tinted in Indian ink only; no coloured drawings will be received. A small elevation on a scale of 2½ inches to 100 feet to be shown on the Craig, enlarged to the same scale, must accompany each design, plan, or model. The successful competitor to furnish plans and specifications, and give such superintendence as may be requisite for carrying his plans fully into execution, for which a commission to be allowed of 5 per cent. on the outlay. First premium, 50 guineas; second, 25 guineas. Should the designer of the first be employed to carry out the design, his premium to be transferred to the next best, and the 25 guineas to the third in merit. Dr. Rogers will, on application, supply intending competitors with a topographical outline of Abbey Craig and the adjacent hills.

Bourton, Warwickshire.—The alterations at the Church of Bourton, near Rugby, have been recently completed. A north aisle has been added, and separated from the nave by arches of early character, corresponding with those on the opposite side; the north transept has been rebuilt from the foundations, and suitable decorated windows have been inserted. A small recessed porch, gabled flush with the aisle wall, serves as a means of communication with this transept, which is used chiefly as a mortuary chapel for the Shuckburgh family, and contains an interesting Gothic monument against its south wall. Some new seating of plain but substantial character takes the place of some very objectionable pews. The works have been executed, under contract, by Mr. Parnell, of Rugby, the outlay being about £600.

A colossal statue of Victory has just been placed in the garden of Apsley House. It is stated that it will form part of the monument to be erected in St. Paul's Cathedral to the memory of the late Duke of Wellington, as proposed by Baron Marochetti.

Iron Bridge for India.—Tenders are invited for the iron superstructure of the Jumna Bridge by the directors of the East India Railway Company.

Digitized by Google

Digitized by Google



June 1869

J.R.Jobbins

MEMORIAL GATEWAY, LODGE, AND LICH HOUSE, NEW CEMETERY, BRIGHTON.

ROBT. WHEELER, ARCHT.

Digitized by Google

THE NEW CEMETERY AT BRIGHTON.

(With an Engraving.)

THE new parochial cemetery at Brighton, situate on the Lewes road, about three-quarters of a mile from the town, was established in 1857. A site containing 19 acres having been presented to the parish by the late Marquess of Bristol, it was decided, that as an expression of gratitude a memorial gateway should be erected at the entrance to the cemetery. The burial board having advertised for designs for the chapels, lodge, and gateway, about twenty sets were forwarded for approval;—those by Mr. Robert Wheeler, of Bedford-chambers, Southampton-street, Strand, were adopted, and ultimately erected under his superintendence. Our engraving shows the Memorial Gateway, Lodge, and Lich-house; the gateway forming the central feature, is built of flint and Caen stone; the niche above the archway contains a statue of the late marquess, and on either side are carved panels containing respectively the arms of the Bristol family and of the town of Brighton.

THE DEPARTMENT OF PRACTICAL ART AT THE ARCHITECTURAL EXHIBITION.

ARRANGEMENTS having been made for an exhibition to be exclusively devoted to objects of a practical bearing upon architecture and building, and which will be opened in the Conduit-street Galleries immediately upon the close of that which now occupies its space, there is less occasion to regret the comparatively scanty show which the department of building materials, patents, inventions, manufactures, &c. contributes to the Architectural Exhibition. We have reason however to know that this deficiency is to be attributed to the very limited space then at the disposal of the committee for such purposes, and that many who had intended to exhibit, and were even making preparations expressly with that view, found every inch of ground pre-occupied when they forwarded their applications. Some of the present exhibitors will retain their places during the next exhibition, and new names have already been handed in: we may consequently anticipate that the forthcoming collection will prove, not only interesting and profitable to all parties concerned, but varied and extensive. Meanwhile, as our examination of the specimens of this class now on view has furnished comments for our note-book, we proceed to transcribe them for the consideration of our readers.

In the North Lobby will be found the chief part of the collection in question, and the first-named in the catalogue is the "London Parquetry Company," who exhibit specimens of panels and moulded decorations of various kinds, including ornamental ceilings, in marquetry and other designs, inlaid with hard woods of various colours, thus admitting of the application of either simple or elaborate kind. We notice also some "patent *waterproof* veneered panelling and wall-decorations," by means of which it is stated that the dampest wall or ceiling can be finished immediately after it has been plastered or cemented. The principal advantages of this system are:—1. The introduction of wainscot, walnut, mahogany, maple, and other fancy woods, as internal decoration, instead of ordinary pine, painted or varnished. 2. Its adaptability to any degree of ornament and to any style of decoration, being capable of application in panels of unlimited dimensions without visible joints, and, if necessary, without any joints at all. 3. It thoroughly resists the effect of any dampness that may arise from the walls, and offers no combustible material in case of fire. 4. It cannot by any means shrink or warp, nor is it liable to crack; and finally, the price for even the simplest design, in fine figured woods, scarcely exceeds *one-half* that of the old-fashioned solid panelling in plain oak, and is cheaper in proportion as it is more ornamental.

There are also some portions of "parquet floors" prepared by this company, suitable for dwelling-rooms or public buildings, and executed in wainscot, walnut, birch, maple, and tulip-wood. These patterns are all *plated* with ¼ inch hard woods upon inch ground work, and require no intermediate floor on the joists. The experience of this company enables them to recommend this system in preference to the "solid" inlaid floors originally introduced by them into this country, though in exceptional cases these are still executed by them without any extra cost.

The adjoining space (2) is occupied by "Encaustic Tiles, &c.," manufactured by Messrs. Minton, Hollins and Co., illustrated in a variety of ways, such as for paving, wall surfaces, panelling, or merely ornamental. There is a large tile, 12 inches square, inlaid with the royal arms, and a medallion of circular form, manufactured for the Capitol at Washington, and ornamented with a figure of Peace. The Patent Architectural Pottery Company, Poole, are also, as heretofore, exhibitors in this material, as Messrs. Maw and Co., to whom we shall have occasion again to refer.

Mediæval metal-work is, as heretofore, worthily represented by "divers cunning craftsmen." The names of Messrs. Hardman and of Messrs. Hart are guarantees for excellence in this department; and Messrs. Johnson and Co., who have a stand in the large gallery, have made great advances this year. We miss, however, Mr. Skidmore's tasteful ornamental work, and also Mr. Potter's. Messrs. Cottam and Co. send several works in metal, which are exhibited in (13); one of these is a handsome Jacobœan gate of large dimensions.

That beautiful material, serpentine marble, again attracts by its charming qualities of colour, veining, and admirable polish. No material, English or Foreign, equals this stone in brilliancy of colour, or in elegance of appearance; and the lower beds of the Signal-staff quarry, near the Lizard, are now realising the predictions of Sir Henry de la Beche, who indicated this as a particularly promising locality. All marbles having carbonate of lime for their base are acted upon immediately by grease and ordinary acids; but serpentine is an igneous rock, and, having a different composition, resists not only the application of grease, but also of sulphuric and muriatic acids. The Lizard company state that "Serpentine is no less fit for external ornament than internal decoration, as it is proved to be more durable than granite, and to retain under all conditions of the atmosphere its polish, which is produced by friction." As examples of its application, we have before us a chimney-piece, some vases (large and small), a tazza, chess table, two balusters, and a specimen of paving (cube pattern).

Messrs. Hobbs, Ashley and Co. have in (6) a great variety of locks, from the simplest to the most complicated construction. Among these are specimens of what they term their "Patent Economic Self-adjusting Mortice and Rim Lock furniture," suitable for locks and latches of all descriptions, and easily applied.

The next case (7) contains articles of a similar kind, forwarded by Messrs. Pugh and Co. These are all well finished, and more than usually tasteful. Some very handsome door-knobs in particular will be observed, and in great variety of material and pattern.

Messrs. Charles Botten and Son, and Messrs. Hayward, Tyler, and Co. exhibit improvements in water-closets (Nos. 8 and 9). "The Patent Regulator" of the former is a vessel containing a diaphragm raised by the action of the closet handle or seat, causing the outer chamber to fill (through the bottom valve) with air, which air, escaping only through a small aperture at the side, prevents the rapid closing of the supply valve, and this escape-hole being enlarged or diminished at will, regulates the flush of water, and dispenses with cisterns, service-boxes, &c. Of their "valve" closet, several are fixed in different parts of the premises. The bottom valve has a glass face, and shuts against vulcanised india-rubber, which experience shows to be the best, soundest, and most durable material to use. They show also a "Patent Slide or Sluice Valve," the peculiarity of which is, that the gun-metal faces can be removed for repair or renewal without taking out the body of the valve, or breaking the joints, or in any way disturbing the mains. In "Howard's Patent Regulating Valve," exhibited by Messrs. Hayward and Co., the simplicity of its construction is its great advantage; it being not liable to get out of order, or to leak; besides which, being entirely unaffected by damp, it may be fixed in the wettest situation without injury. Mr. Jennings, whose show of articles of this class has been usually so large was this year disappointed in his intentions of exhibiting, owing to want of space in the rooms.

No. 10 is called a "Design" by Mr. D. O. Boyd—whose establishment forms part of the ground-floor of the Exhibition galleries —representing his improvements in the construction of smoke and air flues, whereby a separate and effective ventilating flue is provided for each room of a house, without increasing the bulk of the chimney stack, or reducing the sizes of the smoke flues.

Now that brick has become so important a material in an ornamental as well as constructive point of view, it is not to be wondered at that so many modes of its application should be

Digitized by Google

discovered, and that manufacturers should vie with each other in endeavouring to bring it to perfection. In point of colour we have now almost all the varieties that can be wished; but perhaps the red, which is the most sought after for decorative purposes, has hitherto been the least successful. The white is now very fairly accomplished, as may be seen in the Norton Works specimens exhibited (15) by Messrs. Fayle and Co. These white facing bricks, and architectural moulded blocks, approach very near in colour and appearance to stone, and in quality are described as superior to any other facing. (These moulded blocks may be made of any dimensions or pattern). Some of the specimens exhibited are similar to those used at the Middlesex Industrial School, Feltham; and others like those made for Harrow Schools. There are also some good specimens of fire-brick,—tested at the Arsenal at Woolwich,—and also of paving tiles, superior in hardness and durability to Portland stone, and much less in cost. Other specimens of "model bricks" in various forms are supplied (12) by Messrs. Norman, of Burgess Hill, near Hurstpierpoint.

Doulton's stone-ware is too well known to require recommendation; suffice it to say, therefore, that it is not altogether unrepresented here. Mr. Moore's ventilators also are now so generally in use that they need no description. In (14) are a few specimens designed specially to meet the requirements of different kinds of buildings, and with good success.

We have on previous occasions, drawn attention to the marvellous imitations of various woods by Mr. Kershaw; these are grained by a patent process, on painted work; also on deal and bay wood without paint. The specimens this year in (16) are if anything superior to former ones.

No. 17 is a "specimen of bronze work in combination with marble and wood," submitted by Mr. W. Potts, whose endeavours in this line have met with high commendation. The specimens on view are mantel-pieces and sepulchral monuments, constructed with a view to economy, durability, and beauty. As both classes of these works are constructed on the same plan, viz., that of making the architectural fabrics in marble or stone, and adding the sculptural or decorative features either in metal-work (electro deposited in solid copper, and rendered massive by a lining of cement), or by peculiarly beautiful effects in painting on glass, they possess durability in the fullest sense; while, as to cost, it appears that they will vary from about one-third to one-fifth of the expense of such designs in sculptured marble.

A very large space in the East Gallery is occupied by Messrs. Maw and Co.'s Mosaic and Encaustic tile pavements, an extensive series of patterns for which has been designed by Mr. Digby Wyatt with considerable ingenuity and taste. These patterns are here practically worked out, and enough of each is given to convey a true idea of the general effect; the prices also being in every case affixed, ample facilities are afforded for forming a correct judgment in also a business point of view.

Mr. Hart (of 69, Fleet-street) exhibits a little article which has now successfully stood the test of eighteen month's trial; and, now that gas is so generally introduced into buildings of every description, it is one that will probably ensure a large demand. It is styled the "Economising Burner, and Illuminating Power Diffuser," and is a simple contrivance which can be affixed to any gas chandelier, stand or bracket in a few moments. The evil which necessarily arises from the great variation of pressure in the mains is remedied by this apparatus, while it also increases the brilliancy of the light. The current of gas is so regulated that under any circumstances it will permeate with its natural velocity; and, this being attained, all noises caused by overdue pressure are obviated, and at the same time all flickering is prevented.

Messrs. Cox and Son have a handsome stand, in the principal room, devoted to articles of church furniture and decoration. This is a branch of art which they make an exclusive study, we believe, and we can cordially recommend their productions both on the score of correct taste and moderate charges. We have before had occasion to notice their work approvingly; and, now that a new element is introduced by which wood carving is by machinery brought into a roughly-finished state with so much ease, we may expect still more available results.

In the same room also are two solid doors, novel in design, and more especially in decoration. The architectural portions are due to Mr. Waterhouse, of Manchester,—the gentleman who has just carried off the first premium for the new Assize Courts there,—and the design and execution of the decorations to Mr. J. Aspinwall. The "*Drawing*-room door" (367) is in the Italian style, very simple in its treatment, and depending chiefly for effect on its coloured decorations, which are chaste and elegant. The inclosing frame is more architecturally enriched than the other portions, the prevailing colours being red, buff, and green. The surface of the door has three panels, and the enrichments consists of a series of prettily-devised subjects, suggested by portions of Shelley's poem of the "Sensitive Plant." The "*Library* door" (368) is based upon Gothic details, but the modifications, we confess, are not quite to our taste. Nor is the finished colouring so successful as in the other case, though it is far from being devoid of merit. Some conventionally-ornamented panels are of peculiar excellence, and much more in keeping than the diapers, &c. on the architrave jamb and head.

In (262A) M. Desachy exhibits several specimens of his manufacture, called "*Le Stuff*," which is peculiarly suited for internal enrichments, being easily moulded and exceedingly light. One of the practical evidences on view is a portion of the handsome show-room preparing, from the designs of Mr. Owen Jones, for Messrs. Osler, of Oxford-street, the treatment of which is so peculiarly novel as almost to baffle description, at least with any degree of conciseness. Those of our readers, however, who have visited the New Crystal Palace Bazaar have seen the same idea carried out in its fancifully-devised ceiling, and polychrome lights in its interstices. Another specimen in the gallery is a length of one of the front divisions of the Queen's box at Covent Garden Theatre, designed by the architect, Mr. E. M. Barry. This specimen measures 12 feet in length, and is full 3 ft. 6 in. in depth, yet weighs only 87 lb.

Mr. Owen Jones' name appears also in connection with another subject of internal decoration, viz., *paper hangings*, of which a great variety of patterns are to be seen in Messrs. Trumble's specimen book (190). A great many of these have the same geometrical outline, but when printed in various colours, they produce very different effects, as is often observable in paving tiles. The patterns in question are all *on the flat*,—the only correct style of decoration for such purposes.

Our notice of this department of the exhibition must be concluded by a reference to the two or three models on the large marquetry table in the Great Gallery. One is of the church now completing in the Italian style, from the designs of Mr. Tite, at Gerrard's Cross, near Uxbridge, which has at least the attraction of novelty. The model is so contrived as to show all parts of the building, and has been very creditably executed, to a scale of one inch to five feet, by the clerk of the works, Mr. J. Monteath.

A model of the roof over a new chapel on Highgate Hill, and another for contriving two staircases within the same area as would be required for one, will be viewed with interest. The latter scheme in particular is highly ingenious, and one that might frequently be adopted with great advantage.

A model, in cardboard, of Heckington Church, Lincolnshire (369), by Mr. R. J. Johnson, is the only specimen of the kind in the exhibition. Every detail of this exquisite and well-known building is truthfully expressed,—even the subdividings of the mullions and cusping in the windows,—and the whole is an evidence of what persevering industry can accomplish.

ARCHITECTURE AT THE ROYAL ACADEMY.

THE impression conveyed by the aspect of the pictures generally in the Academy exhibition this year,—that it is destitute of leading attractions, and perhaps hardly of average merit taken as a whole,—is certainly correct as regards the Architectural contributions. When however it is remembered that an exhibition of works exclusively of this kind was but recently opened in Conduit-street, and presents a goodly array, we can hardly be surprised if the walls in Trafalgar-square suffer both in point of numbers and choiceness of subjects. True, the half of the North Room is again allotted to architecture; but this, we once more repeat, is but a paltry instalment of the space which it is entitled to claim from an institution bound by its charter to encourage that art equally with those of painting and sculpture. What chance have our delicate drawings (we speak of legitimate architectural works) when, as now, interspersed with and overpowered by a host of gaudy oil paintings. Were the profession as alive to its own interest as it should be, it would not succumb to these repeated indignities, but insisting on its rights, would never rest till it regained the sole possession of an "Architectural Room."

Digitized by Google

Besides the very few oil paintings of architectural subjects which are to be found in the other rooms of the exhibition, we can number in this only between sixty and seventy, while scarcely any, as we have said before, are of superlative merit, or have been contributed by leading men in the profession. With neither of the Barrys, no Cockerell, no Scott, no Donaldson, no Hardwick; Sydney Smirke represented by a single drawing, and David Roberts in less force than usual; the insipid character of the collection may be easily inferred. (1030), "Winchester," gives a faintly distant glimpse of that venerable city, beautiful from any point of observation, and especially the one in question. (1027) shifts us into the neighbouring county, to recal to view that charming bit of mediæval domestic work, the Manor-house at Great Chalfield, Wilts, of which geometrical delineations have been published in one of the supplements to Pugin's 'Examples;' while (1026) transports us to a remote scene, "the Monastery of Smolnoi, on the banks of the Neva, at St. Petersburgh." Netley Abbey is an English ruin, familiar to most tourists in the south, but of which the picture before us (1034) gives but an inadequate idea. There is not much to study in the "Ruins of the villa of the Emperor Commodus, near Rome" (1035); but Mr. Falkener's "Oriental sketches" will invariably repay examination. This gentleman sends no less than five pictures, all in his peculiarly careful style, and illustrating classic remains in Asia Minor. Among these, (1037) the "exterior of the Mosque at Ballat" will be noticed as an example of great *breadth* in composition: some coloured materials and trellis-work enhance the general effect, which is still further heightened by the marble shafts which occur here and there, while the simple dignity of the whole is preserved by the plain comprising arch, unrelieved by moulding or enrichment of any kind. (1058)—in another part of the room, unfortunately—shows the interior of the same mosque; (1086, 1087) represent "the city of Pinara," in Lycia, and "Adalia, the ancient Ataleia," also in Asia Minor. The former of these views is taken from the ruins of the theatre, and includes the lofty rock of the Acropolis, some hundred feet in height, and studded with countless tombs.

(1047), Allsopp's New Brewery, and other buildings, in course of erection at Burton-on-Trent, from the designs of Messrs. Stephenson and Hunt, are on a most extensive scale, but do not appear to possess much architectural pretension. They are shown by a bird's-eye view, unfortunately not accompanied by any plan. "Christ's College, Brecon" (1050), is one of the two excellent drawings contributed by Messrs. Prichard and Seddon, but here again the want of a plan as a key to the arrangement of the buildings is manifest. Under such circumstances criticism is fettered, and the most that can be safely adverted to are the strictly architectural features. In the present case, though there is no great display made, the disposition of the several masses is happily balanced. It may be worth reconsidering (inasmuch as the design is to be modified previous to execution), whether the windows generally are not susceptible of improvement: there is variety, but hardly of the right kind. The design for remodelling "Eatington Park, Warwickshire" (1109), by the same architects, is, in every respect, a contrast to the preceding. The fault here is a redundance of ornament, and that of a very florid kind. Besides the sculptured and carved ornament, the wall surfaces contribute to this effect by the striped and banded work with which they are covered. In the arrangement of this idea of the design considerable taste is shown, as well as in the composition of the principal oriel windows in the two gables. A showy columnar arcade-screen, which stretches on each side of a somewhat fussy entrance-porch, all across the centre of the front, has an unmeaning look, and is the chief drawback in point of detail. The grouping of the whole is exceedingly picturesque.

(1049), "A Design for the Interior of a Chapel" we refer to as a specimen of modern Gothic only slightly removed from the carricatures which Pugin held up *in terrorem* in his memorable 'Contrasts.' Mr. Blackett has consulted the economical movement of the day by using thin walls, which, therefore, luckily will not admit of a proper series of mouldings; moreover, the slender columns which support the arches favour the non-obstructive principle, and are so far also in keeping. Galleries, too, are introduced, but not with satisfactory effect. The best feature is the open timbered roof, which is polygonal, with arched principals springing from corbels.

Mr. Ashpitel's famous picture of ancient Rome finds this year a worthy pendant in his view of the "Modern" city. The spectator is supposed to be among the ruins of the Palace of the Cæsars on the Palatine Mount, and to look across the terraces of the Farnese Gardens upon the Capitol, the Forum, Via Sacra, the Quirinal, the Colosseum, &c. (1052), Mr. Sang's design for decorating the new music hall at Lord Derby's seat at Knowsley, is sufficiently showy and tasteful. By-the-bye, we should have our doubts, from the appearance of the room in this view, as to its good acoustic properties; the succession of domical compartments in the ceiling suggests an adverse opinion. It appears, however, to have been erected expressly for the purpose by Mr. Sydney Smirke. Mr. Sang also exhibits another gorgeous specimen of his art in (1057), the very elegant apartment in Hatfield House known as King James's Room. The ceiling here is flat, and covered with a series of elaborate interlacing panels, such as are not unfrequent in Elizabethan mansions. In (1124) he has yet another work of the same kind, but on a more extended scale: it is to decorate St. George's Hall, at Liverpool. Although we have nothing whatever to urge against Mr. Sang's proposed method of decorating this building, so far as we can make out what is indicated, it is almost needless to observe that the utmost care should be taken that no step so weighty as that now proposed should be resolved on without due consideration. This hall, as a whole, has now no rival among the similar edifices of our country, and it behoves us how we meddle with that purity of architectural detail which constitutes its especial charm.

(1053) Is one of the many new domestic buildings which find representations on these walls, and is, altogether, a very fair specimen. It is in course of erection at Bromley, Kent, from the designs of Mr. E. Ellis, who has turned the simple material of red brick to good account. The two windows, side by side in the gable, mar the otherwise pleasing expression of this design. The "Cartoon for one of a series of painted glass windows to be placed in Southwell Minster," from Mr. O'Connor's designs, occupies the whole of one of the Norman single lights, and illustrates effectively the parable of the Good Samaritan. The "Porch at Ludlow Church, Salop," by Mr. Pedley (1055), is chiefly of Early Geometric date, with subsequent additions; the fabric is now undergoing a thorough repair and restoration.

The "Morning Room" (1061), at Ashbridge (a seat of the Earl of Brownlow), has given Mr. Digby Wyatt an opportunity of indulging in his favourite Renaissance style, and he has certainly availed himself of the resources of that style with considerable ability. Nevertheless, a frequent repetition of such works would not tend to improve our national taste. Decidedly in contrast with this, as regards conception, is its neighbour (1060), Mr. Sydney Smirke's "Interior of a small church proposed to be erected in Yorkshire." This is further described as being in the "Early Christian style," which turns out to be nothing more or less than a simple *basilica*. As a set-off to the tameness of its parts, coloured decoration is lavished throughout; blue and gold being the predominant hues. The columns between nave and aisles are apparently of marble (green), and the pavement is of a rich tesselated pattern. The roof is open, the trusses being of the ordinary king-post construction, such as were common in "early" times.

Mr. Murray exhibits three clever drawings: (1062) the "exterior," and (1100) the "interior" of the proposed Roman Catholic church at Cork, are unfortunately hung quite separate from one another. The former is also too much above the eye to admit of an examination of the details, but the general outline is noble. Internally, the design of the roof, which is open-timbered, is as ingeniously contrived as it is novel. In (1076) and (1113) we have respectively the "interior" and "exterior" of another of the competition designs for the same building, by Mr. J. P. Jones. The difference in appearance of these two designs is every way most striking, while each can point doubtless to orthodox authorities; but in the one case these are altogether English, and in the other they are exclusively foreign. If the one aims at too little effect, the other certainly aims at too much. We leave the question of cost entirely out of the consideration, though in this there would be necessarily a proportionate difference.—Mr. Murray's remaining drawing is (1168) "Design for the proposed National Schools, Leamington," one of the prettiest and most skilfully coloured little pictures in the room.

One of the "Designs for Heigham Church, near Norwich," for which several others are in the Architectural Exhibition, is numbered (1064), and is by Mr. J. Nicholls. It appears to be intended to be constructed chiefly in flint, the usual material in that district: the design is of early character, and has a well-pro-

Digitized by Google

portioned tower and broach spire at the west end of the aisle, but is otherwise poor. No. 1063, "Design for the new Government Offices," by Mr. Granville, is essentially of French type, like some portions of the Louvre or our old British Museum; but not treated with anything like the same skill:—no plan is appended. A more comprehensive design for the same object is exhibited (1071) by Mr. H. R. Newton, in a large bird's-eye view, which shows the proposed buildings entirely occupying the area, both east and west of Parliament-street, between Whitehall and Westminster Bridge. The style is Classic, and a prominent feature in the plan is the large circular open court, surrounded by a handsome colonnade.

There are four telling drawings by Mr. Billings, boldly tinted, and representing different works now being carried out under his designs and superintendence. The most important of these is the first mentioned in the catalogue (1068), and consists of an extensive range of street architecture,—a "warehouse at Glasgow." In this design the author evinces his thorough acquaintance with the peculiarities of Scotch architecture, and he has contrived to infuse not a little of its true spirit into the design under notice. (1121) and (1148) illustrate respectively the Vicarage at Kemble, Gloucestershire, and the entrance Gateway to the mansion of Robert Gordon, Esq., at the same place. In these, as well as the remaining picture, (1156) "Crosby Church, Cumberland," a like versatility of idea is perceptible, and all partake more or less of the same school in which Mr. Billings has so laboriously studied.

Mr. Street is an exhibitor of only one picture (1069), but it embraces two designs for churches he is about to erect in Yorkshire and Hampshire. They are drawn in the author's excellent pen-and-ink style, and are completely illustrated by ground plans as well as external and internal perspectives. While both designs are noticeable for their unpretending simplicity, each possesses an individual character which is well preserved in the subordinate details. A clever adaptation of the plan in one case provides for a picturesque grouping of the shelter over the west entrance with the square dwarf tower at its northern end. The way, too, in which the latter is converted to an octagon in the upper stages is very well managed. We notice in the second design that the chancel roof is made higher than that of the nave.

A very well drawn and elaborate elevation next claims attention (1070), being "A design for the south front of a National Institute of Arts and Science, adapted for the site of Burlington House, Piccadilly," by Mr. J. B. Waring. It presents a curious admixture of the details of all styles of architecture, for it is amusing to observe how Gothic buttresses are interchanged with rusticated Italian piers, and how Classic, Saracenic, and Byzantine features are amalgamated. The elevation forms however a thoroughly symmetrical mass, each extremity being terminated by a cupola surmounted by a glass dome, on the ridge-and-furrow principle. Carving and sculpture are freely introduced in various places with success, but though novelty and ingenuity are manifested throughout, we cannot imagine that in execution such a building would have a satisfactory appearance. It is an effort to produce a new style by combining the details of existing ones; but, to whatever extent this may be allowable, it must be evident that incongruities, such as could be readily pointed out in Mr. Waring's scheme, are by no means admissable.

In Mr. Macquoid's view of the "Cathedral at Autun" (1073) we have a picturesque drawing of a not very satisfactory piece of architecture; but his view of Hampton Court (1145) is an eminently truthful and characteristic picture,—one of the best, certainly, in the room, and which deserved a better place in the hanging. (1074) is a capital sketch of the Tomb of Queen Philippa, in Westminster Abbey, slightly tinted, and by Mr. H. W. Brewer. In (1079) the subject of the Islington Vestry Hall is brought into notice by Mr. Barnett's design, in praise of which there is not much to be said. It is very ordinary Italian, principally marked by its portico of four rusticated columns. By its side (1084) is Messrs. Legg's design for the *Chelsea* Vestry Hall, designed in the same style, but equally poor. It shows an artificial mode of contriving a central feature, by raising the middle of the façade an additional story, as a mere screen, the would-be window openings being absolutely perforated.

(1085) is a mansion, by Mr. Penson, very consistently treated in every way. It is here shown complete, with a plan and several sketches of bits of the interior, also small elevations of the different sides. It has the merit of not being overdone in ornament.

The new Westminster Palace Hotel, the scene of the late melancholy accident, is represented in (1088) by an interior view of the centre hall, which is a large handsome area, four stories in height, and having a flat ceiling trabiated and coffered. The windows partake of the Byzantine type, and, with the other parts, have a good deal of enrichment. The galleries for communication across the ends of the hall are an excellent idea well worked out.

The Royal Albert Asylum, Cambridge (1089), by Mr. Peck, is an unpretending building of good outline; the bands of colour in the material are well introduced. The Choir of Sherborne Abbey, by Mr. Slater (who has recently completed the costly restoration there, commenced by the late Mr. Carpenter), is shown in a large and highly-finished outline drawing of the interior (1091). The magnificent reredos forms a prominent object, and so do the oak fittings; the design of the stall and seat ends is particularly good. The style throughout is Perpendicular, and local peculiarities have not been lost sight of.

Mr. W. Webbe's "Normal College Training Schools, Upper Bangor" (1092), form an excellent group, but have the fault of too much "prettiness," as is frequently observable in his designs. (1097) is decidedly the reverse, as indeed it should be. It shows the "New entrance to Gosford Castle, Armagh," by Mr. G. A. Burn, who has duly preserved the associations connected with the look of impenetrable walls and round towers, portentous machicolations, battlements, and the like. The material is native granite.

Mr. Talbot Bury sends but one drawing (1098), a view of "New Lodge, Windsor Forest," now in course of erection by him for the Belgian Minister. This is really a sensible-looking building, and shows, in its tasteful and unexaggerated details, the author's thorough acquaintance with our mediæval domestic architecture. From Gothic to Classic, from ancient to modern! Such is the destiny of those who follow the leading of the Exhibition catalogue. We next come to the "Arch of Titus" (1099), a very masterly delineation, by Mr. Binyon, and then to (1102), Mr. Dobbin's highly-wrought view of the "Court of the Lions" in the Alhambra, a subject, with all its gorgeousness, not worth practically the pains here bestowed. It is a miracle of work. (1101), "The Hendon Union Schools," just completed from the designs of Mr. C. H. Cooke, is apparently an unusually large red brick building, plain in character, but well balanced; the style Elizabethan. We should like to have seen a block plan.

We cannot pass the "Drawing from Mr. Foley's equestrian statue of the late Lord Hardinge," at Calcutta (1103), without a word of admiration at so noble a memorial; and we may mention, while on the subject of sculpture, the skilful "Monumental effigy of Queen Catherine Parr" (1259), about to be placed in Sudeley Castle, Gloucestershire, where she lies buried. The figure is executed in marble, with every attention to the costume, &c. of the period, and is highly creditable to the sculptor, Mr. J. B. Philip.

(1108), "The drawing-room, library, and other additions to Barton Manor, Oxon," by Mr. S. S. Teulon, form a good group. The style is Tudor, the walls are of stone, with red brick ornamental chimney shafts. The entrance porch is absurdly overwrought; and (1110), by Mr. Joseph James, shows his design, submitted in private competition, for a mansion and farm buildings near Halifax. The style selected—the castellated Tudor—was possibly suggested by the bold nature of the site, and its characteristic features certainly harmonise. The upper portion of the large tower is, however, weak in outline, but the oriel in the building below, corbelled out from the buttress, is very well managed.

The principal merit of Mr. Brakspeare's design for restoring Bowdon Church, Cheshire (1111), is that it preserves as much as possible of the present structure, which, though of the latest period of Perpendicular, has that peculiarity of breadth of parts, produced by repetition, which is not uncommon in works of that age, and which, as a principle, we in the present day are too apt to ignore. (1112) "Long Hall, Guisborough," is a not very prepossessing looking dwelling. The plan shows it to be spacious, but does not appear to be well arranged. (1114 and 1125) exhibit the exterior and interior of a "Design for a Jardin d'Hiver, for H.I.M. the Sultan of Turkey." The Crystal Palace type has been naturally followed, but not servilely, indeed Mr. Lane may be complimented on many variations which give his design an air of individuality, besides contributing to the special requirements of its continental destiny. (1118) is a distant hazy view of the would-be Gothic palace of the Archbishop of York, at Bishopsthorpe. On Mr. Spurgeon's new tabernacle we have already

Digitized by Google

sufficiently descanted, otherwise we might comment on (1119), in which Mr. Pocock shows a well-finished perspective of his design "now in course of erection." (1120) is the garden front of a handsome mansion,—Cromwell House, Mortlake,—exhibited by the architect, Mr. R. P. Pope. It is a clever intermixture of northern and southern Gothic, but, if any thing, is too frittered and pretty. The material is red brick, with black bands.

In (1122) Mr. I'Anson has another adaptation of southern Gothic, applied to "Merchants' offices, Mark-lane." It bears a marked resemblance to the handsome chambers which the same gentleman has erected in Fenchurch-street. (1123) "Competition design for a church at Berne," by Mr. Pedley, is not sufficiently foreign in its aspect. There is also a prevalent tone of fussiness, which detracts from the dignity which such a building should assume. In the design of the low central tower the author appears to have had in view our fine English specimen at Melton Mowbray. The whole is well illustrated by a plan and two interior perspective sketches.

Mr. Goldie's "St. Peter's Church, Scarborough" (1130) partakes quite as much of Italian as of English Gothic, both in form and details. A well-proportioned octagonal apse is an important feature in the plan. Externally, the best portion is undoubtedly the tower, placed at the south-west angle. The domestic buildings shown in connection with the church are very well designed. We are glad to observe also the small plan.—(1131) "The Telegraph Station, Threadneedle-street," by Mr. Horace Jones, now nearly finished, is one of the most showy of our modern city buildings. It is in the French style, and the flatness of the front, which is still too apparent, is relieved by an abundance of excellent carving. The turret surmounting the whole has great play of outline, and has evidently been carefully studied.

(1132) "Design for Mortuary Chapels at Sudbury," by Mr. Moye, is in the ornate Gothic style, and the two-and-two uniform arrangement. (1133) is a gloomy and not very successful view (internally) of the Temple Church. The spectator is supposed to be in the circular vestibule, looking eastward.

(1137) Is a somewhat original idea for the Ellesmere Memorial, by Mr. H. S. Ridley. It may be briefly described as a square pillar or obelisk, shafted at the angles, and resting on a substantial base enriched with festoon and other carving. It was classed as one of the six selected designs, and seems to have deserved the honourable mention which it obtained.

(1138 and 1139) Are views of two mediæval and classic ruins—Kenilworth Castle, and the arch of Septimius Severus, at Rome; —both well given. On (1140), "A memorial cross now in course of erection to the memory of the late Dean of Llandaff," we are rather at a loss to speak. It appears to be an almost exact reproduction of one of our ancient *churchyard* crosses, and their usual situation. Its base is well composed, but the upper part is too spiky.

Mr. Edmeston sends a beautiful drawing (1135) of the Great Gallery of the Architectural Exhibition, Suffolk-street. It has, however, this fault, that it conveys an exaggerated impression of the actual length of the room, and thereby injures its proportions, which in reality are very good. Mr. Gray's "Villa about to be erected at Highgate Rise" (1144) is, like most of his works, clever and picturesque. It is *really* in the villa style. We cannot bestow approval on Mr. S. S. Teulon's "additions to Shadwell Court," as here delineated. The style is Gothic, but badly and coarsely handled; less successful than most of the author's works. (1147) "Interior of Heywood Church, Lancashire," is one of Mr. J. Clarke's best designs. The proportions are especially good, and so is the open roof. There is some novelty in the management of the clerestory windows, which are coupled in each bay, and separated by detached marble shafts

A fine interior of "Durham Cathedral" is exhibited by Mr. Brewer, in (1150). It is taken at the junction of nave and transept, and shows to advantage the stupendous Norman pillars, covered with zigzag work. Of (1151), "Design for a building in place of the present National Gallery," suffice it to say, that it here presents no shadow of a recommendation. Unworthy as may be the present building of occupying "the finest site in Europe," the one before us would be no improvement. The "new schools in Theobald's-road" (1152), are highly creditable to Messrs. Wigg and Oliver, from whose designs they were erected. They are of red brick, deep in colour, and the plan is ingeniously contrived, so as agreeably to break the monotonous line of the street frontage. A circular staircase in the angle aids the general effect.

"Wallasey Water Tower" (1153), by Mr. Rawlinson, is a heavy-looking square mass, dotted on the surface with a host of little windows. The design is not equal to many we have seen from the same hand. (1155) the "Entrance lodge erected at Whittlebury," by Mr. G. Morgan, is a pretty specimen of the simple Palladian style;—(1165) an interesting india-ink sketch of the "ancient wooden porch at Merton Church, Surrey," by Mr. J. D. Wyatt; and (1169) a distant view of Baron Rothschild's magnificent seat at Mentmore—not very flattering. An interior view of the "Britannia Theatre, Hoxton" (1167), lately completed from the designs of Messrs. Finch, Hill, and Paraire, makes an excellent picture. Apart from this the whole conception is unusually good and well carried out.

Into the subject of the Exhibition generally we are not in the habit of venturing; but here and there one out of the thirteen hundred objects chances to be an architectural one. This year they are fewer and less interesting than usual. David Roberts has a masterly interior of St. Mark's, Venice (420), and a fine exterior (160) of Baldassare's noble church of Santa Maria della Salute, in the same city, though it has been objected that, as here painted, it does not look to be of its real material—white marble. Mr. Brandard has (590) a small but pretty view of the "North transept of Tintern Abbey;"—(608) is a grand picture of "Hieropolis, Asia Minor," by Mr. H. Johnson;—(611) a pretty bit of old English domestic work — the "Fishing house, near Marlow;"—(643) by Mr. Stanfield, jun., is a view of the "Grey Friars' Tower, Richmond, Yorkshire,"—careful, but rather hard; —(709) an elaborate picture of the "Grand staircase, Burgos Cathedral," by Mr. Dobbin;—(718) that picturesque ivy-clad ruin "Chingford Church," hung too high up to be properly seen;—(840) "Hayes Church, Kent,"—very poor;—(923) "St. Wulfran, Abbeville, Picardy," by Mr. A. J. Wood, nicely shown;—and (924) "Pæstum," will be viewed with interest. There are some few others of minor importance.

ON THE RELATIVE VALUES OF COKE AND COAL IN LOCOMOTIVE ENGINES.*

By Benjamin Fothergill.

Having attended a meeting of the Society of Arts, on December 2nd 1857, and taken part in the discussion relating to the use of coke and coal in the furnaces of steam-engine boilers, I then undertook to lay before its members the results of a series of experiments which I had made with coke and coal in locomotive engines in corroboration of the truth of my assertions.

First, that coal was decidedly superior to coke in respect to heating power, and consequently more economical;

Second, that a plentiful supply of steam could be generated by the use of coal for working engines at high velocities and for drawing heavy trains;

Third, the capabilities of coal-burning engines for consuming their own smoke; and,

Fourth, the increased durability of fire boxes and tubes when coal was used.

On that occasion I stated that my experiments had been conducted upon the London and South Western Railway, and were made, at the request of the directors, to ascertain the value of an invention which had been patented by their locomotive superintendent, Mr. Joseph Beattie. In this contrivance the fire-box is divided transversely into two compartments by an inclined water space mid-feather or diaphragm, and a dependent water space hanging from the roof. Both compartments are arched over with fire tiles at narrow intervals apart. The boiler is constructed with a combustion chamber extending to about one-half its length, and it has a vertical mid-feather or diaphragm in the centre running parallel with its sides. The other half is supplied with tubes in the ordinary manner. The object of this contrivance is to increase the amount of direct heating surface and to diminish the indirect or tube surface, whilst the combustion chamber affords sufficient space for the introduction of a series of fire tiles for the purpose of retaining a portion of the heat given off from the combustion of the gases in the fire-box, and for diffusing the unconsumed carbon, as well as effecting a complete mixture of the air with the gases, and thereby producing a mass of flame which is brought in contact with the direct heating surface of the combustion chamber

*Paper read before the Society of Arts

Digitized by Google

before it enters the tubes, and at the same time prevents practically such an escape of smoke from the chimney as could be deemed a nuisance.*

The back or first furnace is the most actively worked, the second being intended to carry incandescent fuel. The ash pans are furnished with dampers for the admission of air when necessary; and also through the small apertures in the fire doors and through hollow stays in the fire-box.

In addition to the mechanical contrivances referred to, Mr. Beattie has another of considerable importance for using a portion of the exhaust steam for heating the feed water before it enters the boiler, and, as I have tried both his contrivances for this desirable object, I need only refer to the one having pipes for conveying the water and steam to a tank under the foot-plate of the engine, from which the feed-pumps receive their supply. The water is received on to a perforated plate in this tank, and in its descent comes in contact with and condenses the steam, and thereby becomes heated; the supply of water is regulated by a ball-tap or valve, and the steam is admitted or shut off whenever the engine driver has occasion to supply or shut off the feed-water to the boiler.

In the course of my first series of experiments, I have used the feed-water supplied by Mr. Beattie's apparatus, at a temperature of 196°.

I may here observe that I was anxious to obtain an analysis of the fuel used by the London and South Western Railway Company, and the more so as I found that they manufactured their own coke from "Ramsay's Coking Coal" (Newcastle), which is of a superior quality; and as it was desirable to ascertain, as far as possible, whether the coke or the coals which were supplied to me contained the greatest amount of sulphur, I sent samples of each to Mr. Dugald Campbell, Analytical Chemist to the Brompton Hospital, London, and he, after a careful examination, furnished me with the following statement, viz.—

"The samples I received were four in number, and marked as follows:

No. 1.—Ramsay's coking coal.
No. 2.—Coke, made from ditto.
No. 3.—Llanguathog Merthyr, shipped Swansea, Neath, and Cardiff.
No. 4.—Griff coal.

"*No.* 1.—*Ramsay's Coking Coal*

"Is of a jet sparkling appearance, and is broken up without much difficulty by the fingers into rather thick layers, between most of which are thin plates of iron pyrites, which, I may state, is a compound of iron and sulphur, in the proportion of one of the former to two of the latter. When the coal is reduced to a very fine powder—and in which state it is required for analysis—its jet black appearance gives place to a considerable brown tint, which indicates it to be of a bituminous character.

"The calorific value of a substance is generally estimated in two ways; firstly, by calculating from its ultimate analysis what quantity of water a known weight of the fuel would evaporate from 212° Fah.; and, secondly, by ascertaining how much oxide of lead is capable of being reduced to the metallic state by a known quantity of the fuel.

"These experiments when conducted upon the different specimens of fuel under precisely similar circumstances, and which has been the case in this instance, give results extremely useful for comparing the economic value of the fuel. By such means, 1 lb. of No. 1, Ramsay's coking coal, was found to be capable of evaporating 15·18 lb. of water from a temperature of 212° Fah.; and 1 lb. of reducing 34·99 lb. of metallic lead from the oxide."

"*No.* 2.—*Coke made from Ramsay's Coking Coal.*

"The specimen I received of this substance was a thin column, which, from its appearance, must have occupied a space from the top to the bottom of the coke in the coking furnace. An average sample was selected from this for examination.

"One pound of this coke is capable of evaporating from 212° Fah. 12·78 lb. of water; and 1 lb. of reducing from the oxide of lead, 31·35 lb. of metallic lead."

"*No.* 3.—*Llanguathog Merthyr.*

"This coal has a bright sparkling appearance, resembling to some extent (No. 1) Ramsay's coal; but it is rather more dense, and not so easily broken; when broken however, the layers are not so thick, and between them no iron pyrites are visible, but thin plates of silicate of lime are occasionally noticed.

"One pound of this coal is capable of evaporating from 212° Fah. 14·74 lb. of water; and 1 lb. of reducing from the oxide of lead 34·74 lb. of metallic lead."

"*No.* 4.—*Griff Coal.*

"This is a coal of a dull appearance, dense and hard, with a concoidal fracture, different from either of the other two coals.

"One pound of this coal is capable of evaporating from 212° Fah. 9·8 lb. of water, and 1 lb. of reducing from the oxide 25·14 lb. of metallic lead."

"*Table of Results.*

	No. 1, Coal.	No 2, Coke.	No. 3, Coal.	No. 4, Coal.
Density, water being 1000 ...	1·279	1·055	1·333	1·341
Carbon	85·57	86·91	89·16	66·21
Hydrogen	5·68	1·32	4·06	4·09
Oxygen	3·07	0·10	1·65	11·07
Nitrogen	1 48	0·80	1·21	1·13
Sulphur	1·46	1·94	1·39	1·01
Moisture	0·74	1·28	0·67	9·23
Ash	2·00	7·65	1·86	7·26
	100·00	100·00	100·00	100·00
Pounds of water which 1 lb. of fuel would evaporate from 212° Fah.	15·18	12·78	14·74	9·8
Pounds of lead reduced by 1 lb. of fuel	34·99	31·35	34·74	25·14

"In glancing at the above table, the first thing that arrests the attention is the per-centage amount of sulphur being greater in the coke than in the coal from which it was made, and by nearly a half per cent.

"It appears from my analysis that although in coking coal there may be a notable loss in the per-centage of carbon, hydrogen, oxygen, and nitrogen, in the coke, yet the sulphur has not only not decreased, but has actually increased in the per-centage. I find in the coking oven that not more than one-twelfth of the sulphur goes off from the coal, whilst the loss of the other gases is upwards of one third of the whole.

"But portions of the coke may be found to contain a very much larger quantity of sulphur than I found in the above specimen, and if I had selected a piece from near the top of the column, instead of taking an average of the whole, I should have found very much more than I did.

"The pieces of coke delivered to me by your assistant, which he told me he had taken from a quantity from the tender of an engine in going down to Southampton, on the 2nd ultimo, gave on an average 5·62 per cent. of sulphur, and some which I selected myself from the coke-heap at the Nine Elms station gave about 5 per cent.

"The next peculiarity to be noticed between the coke and the coal from which it is made is, in the amount of ash being very much higher in the former than in the latter; this is caused by an excess of iron and silica principally, and were it not for the increase of ash there would not be so very much difference in their heating power, &c. I can only account for this increase in these two substances from their being volatilised in the coking-ovens, and entering into the crevices of the fuel from which the gases escape.

"It is common to find large quantities of a hairy-like substance adhering to the coke, varying in colour from a light-grey to black; this is silica, with a trace of carbon and iron, and which has been in a state of volatilisation till arrested by coming to a cooler part of the coking-oven, where it has condensed, and is found as I have described it.

"No. 3, Llanguathog Merthyr coal, you will observe, is a coal of a very superior quality, and is nearly equal to Ramsay's coking coal in heating power, and has a very little less per-centage of sulphur; but No. 4, Griff coal, though containing less sulphur than either, does not possess such heating power, which is partly owing to its containing a large per-centage of water; this water is expelled when the coal is reduced to a fine powder, and submitted for some time to a temperature of 212° Fah. The

* For illustrations and description of Beattie's Engine, see *ante*, vol. xxi. p. 270.

Digitized by Google

moisture in the other specimens was determined in a similar manner.

"I may state that my experiments were repeated, and great care was bestowed to verify any results which appeared contrary to what should have been expected, such as the larger amount of ash in coke in comparison to the coal from which it was made, and the larger amount of sulphur in coke than in coal, the general belief being that in the coking of coal most of the sulphur is driven off."

I will now proceed to give a detailed statement as to my mode of procedure to ascertain the quantity of fuel consumed per trip from the Waterloo Station, London, to Southampton and back again, inclusive of the quantity used in getting up steam in the morning and whilst waiting at Southampton. I personally inspected the weighing of the fuel in the morning, and again at Southampton; and on the return of the engine to Nine Elms I took an account of the coal which remained on the tender, and I had the fire-box cleared out, the hot material cooled and riddled, and the worthless portion separated, and I allowed the value in good coal for the remainder.

I commenced my experimental trips with the coal engine Ironsides, which had been constructed on Mr. Beattie's patented plans, for burning coal only, and heating the feed-water, and took the 10.15 A.M. mail train from Waterloo to Southampton, and arrived there at 1.5 P.M. We commenced the return journey at 3.0 P.M., and arrived at the Waterloo Station at 5.58, the engine having performed the trip in a most satisfactory manner, and without any appearance of smoke, save and except when the steam had to be got up in the morning, or the fires prepared for the return journey.

The result of that day's trip will be seen by referring to the tabulated summary opposite November 15th, where the average consumption of fuel is shown as 16·71 lb. of coal per mile, or when reduced to its coke value equal to 11·14 lb. per mile, with an average load of 12·2 carriages per mile, travelling at an average speed of 31·25 miles per hour.

I have said that the consumption of coal, when reduced to its coke value, was equal to 11·14 lb. per mile; in explanation of my meaning, I beg to state experience has proved that, in order to make one ton of good coke suitable for locomotive engines, 1½ ton of the best coking coal is required, and with some kinds of coking coal, 1½ to 1¾ ton are necessary to produce one ton of coke. It will be evident then, that if the same load can be taken at the same velocity and under the same circumstances in respect to weather, with equal weights of fuel, say with coal in engines fitted up with Mr. Beattie's patented contrivance, and with coke in the ordinary class of engines, a net saving is effected of one-third, or 33 per cent., in fuel alone, without taking into consideration the incidental saving consequent on the construction of coke ovens, the interest on capital, the cost of maintenance, and the wages of workmen employed in the manufacture of coke.

From the tabulated summary it will be seen that I worked the coal engine Ironsides for three days with little variation in respect to the quantity of fuel consumed, that little variation arising from the change in the weather. I then selected the coke-burning engine Vesuvius, one of the ordinary class, and being nearest in dimensions and weight to the Ironsides, and in good working order, and with it I took a similar train (10.15) to and from Southampton, burning coke only, and I adopted the same course of proceeding as on the former trips, but with a very different result as regards the consumption of fuel; for, on referring to the general summary, it will be seen that the average load was 12·1 carriages, the average speed 30·27 miles per hour, while the average consumption of fuel was 20·62 lb. of coke per mile. On the following day I took the express train with the same engine, but the results were substantially the same as on the previous day with the mail train.

Having tried the Vesuvius, I decided upon taking another coke-burning engine (the Frome), which was a similar class engine to the Vesuvius, in order to ascertain if there was any difference in the results of their working. On referring to the summary of the trip opposite November 22nd, it will be seen that the consumption of fuel was remarkably near that of the Vesuvius.

I then determined to test the capabilities of another coal-burning engine, the Canute, and compare the results of its working the express train with that of the Vesuvius. The load was lighter, averaging 9·3 carriages, but the average speed attained was higher, being 36·76 miles per hour. The consumption of fuel was 16·71 lb. of coal per mile, the coke value of which is 11·14 lb. per mile against 20·62 lb. per mile consumed by the Vesuvius. —See trip in summary, November 23rd.

The experiments up to this period showed a decided advantage in the coal-burning engines, so far as regarded economy of fuel, &c., but the results were not conclusive to my mind, inasmuch as the engines had not worked under precisely the same circumstances with respect to weather and uniformity of load and speed. I therefore obtained a sufficient number of carriages to form two trains of equal size and weight, and I had a quantity of material weighed and placed in each of them equivalent to a load of passengers. The coal-burning engine Canute was attached to one of the trains, and the coke-burning engine Vesuvius to the other. The weight of the train, including engine and tender, drawn by the Canute, was 170 tons 8 cwt., and that drawn by the Vesuvius 167 tons 12 cwt.

The trains left London and Southampton within a few minutes of each other, so that there could be no difference between them in respect to weather, but lest either train should run heavier than the other from extra friction in the axle bearings, I took a second trip on the following day with the engines changed from one train to the other. I registered the particulars of each day's trip separately (see November 30th and December 1st); but taking the average of the two days' working, the difference in respect to consumption of fuel will be more readily seen.

	Average speed.	Average consumption of fuel in lbs. per mile	Load.
Canute	28·40	Coal 20·36	19 carriages
Vesuvius	27·23	Coke 24·37	19 ,,

Coal reduced to its coke value 13·57, which shows a clear saving of 10·80 lb. per mile.

I subsequently tested the capabilities of the coal-burning engine Canute for making sufficient steam when drawing heavy loads, and as this engine was rather heavier than the coke-burning engine Vesuvius, I obtained an additional number of carriages, and after they had been weighted I had twenty-eight of them attached to the Canute, and twenty-two to the Vesuvius, making the total weight of the Canute train 235 tons 13 cwt., and that of the Vesuvius train 189 tons 6 cwt. I was very desirous of testing the capabilities of the coal-engine Canute for drawing a heavy load up the incline from Southampton to Andover (a distance of 22 miles) without the aid of a pilot engine, and for that purpose I added about 20 tons extra weight to this train beyond its proportionate load.

Early in the morning of December 19th, 1855, we proceeded to Southampton with the two trains, but unfortunately the water pipe attached to the lower part of the boiler in the Canute engine gave way, and the leakage therefrom became so great soon after we left Southampton that we were obliged to pump into the boiler an extra supply of water to compensate for the loss sustained. A reference to the registered account of the trip on that day will show that while the Vesuvius (coke) engine evaporated 7·13 lb. of water by 1 lb. of fuel, the Canute (coal) engine evaporated 9·05 lb. of water by 1 lb. of fuel. The amount of water, therefore, which passed from the tender of the Canute engine was greater by 1·92 or nearly 2 lb. of water per 1 lb. of fuel than that from the tender of the Vesuvius, but notwithstanding that mishap, the Canute generated sufficient steam to draw the 28 loaded carriages up the bank without any aid whatever.

The firing from the same cause was increased, but the result on the day's work of the two engines was still in favour of the coal-burning engine, as will be seen from the summary; and it is worthy of remark, that when the coal is reduced to its coke value the result is 10·30 lb. per mile in favour of the coal-burning engine Canute.

I have shown that the saving effected by the coal-burning engines with the ordinary trains was equal on the average to 8·56 lb. of coke per mile, or 10·80 lb. of coke per mile when each engine worked under the same circumstances as to weather, &c. with equal loads. Now if the former quantity, viz., 8·56 lb. per mile, be taken, the saving is equal to 1·348 lb. on each trip, or at the rate of 187¾ tons per engine per annum, at six days' work in each week; but if the latter quantity (viz. 10·80 lb. per mile) be taken, the saving is equal to 1·721 lb. at each trip, or 239½ tons per engine per annum.

The consumption of coke by the coke-burning engine Vesuvius during one of the trips referred to was 29½ cwt., which at 31*s.* 6*d.* per ton was equal to £2. 6*s.* 6*d.*; whereas the consumption of the coal-burning engine Ironsides, during another of the trips, was 24¾ cwt., which at 19*s.* per ton was equal to £1. 3*s.* 6*d.*, giving a

Digitized by Google

clear saving on the latter per trip of 23*s*. In my report to the directors of the London and South Western Railway Company I stated that if they had seventy engines in steam per day, and each of them was fitted up for burning coal, and all worked under similar circumstances to the Ironsides, there would be a daily saving to the company of £80. 10*s*., or £25,116 per annum.

From the result of these important and interesting experiments I trust I have succeeded in demonstrating the truth of the assertions I made at the meeting to which I have referred,—viz., that coal can be used more economically in locomotive engines than coke; that by the use of coal sufficient steam can be generated to supply locomotive engines when working at high velocities and when drawing heavy loads; and in support of my assertion relating to the capability of coal-burning engines built in accordance with Mr. Beattie's patent, consuming their own smoke, I have to observe that a goodly number of them are at work on different lines of railway, and testimonials of thier efficiency have very frequently been given.

Summary of Experimental Trips made on the London and South Western Railway.

Date.	Name of Engine.	Description.	Average time in hours and minutes.	Average speed in miles per hour.	Average feet consumed in lbs. per mile.	Coal reduced to its coke value.	Quantity of water evaporated per mile per lb of fuel.	Highest temperature of water in tender during each trip.	Load in number of carriages.	Weight of train, including engine and tender.	Remarks.
1855.							lb			Ton. cwt.	
Nov. 15	Ironsides	Coal	2·31	31·25	16·71	11·14	8·29	124°	12·2	...	Beautiful, clear frosty day, and calm.
,, 16	Ditto	,,	2·31	30·68	17·24	11·49	6·72	158°	10·6	...	Damp foggy day; rails greasy for 50 miles.
,, 17	Ditto	,,	2·39	29·71	19·02	12·68	7·07	164°	12·1	...	Clear day, with strong side wind in favour of down and against up journey.
,, 19	Vesuvius	Coke	2·36	30·27	20·62	...	7·15	76°	12·1	...	Wet drizzling rain, with light wind on our back.
,, 20	Ditto	,,	2·26	35·23	20·62	...	7·78	74°	12·2	...	Rails rather greasy; wind against down journey.
,, 22	Frome	,,	2·27	32·14	20·97	...	7·62	94°	13·3	...	Ditto.
,, 23	Canute	Coal	2·11	36·76	16·71	11·14	7·35	166°	9·3	...	Fine clear day, with light wind in favour of down journey.
,, 30	Ditto	,,	2·49	27·65	20·51	13·67	8·26	142°	19·0	170 8	Fine frosty day; rails greasy for first 50 miles.
,, 30	Vesuvius	Coke	2·56	26·54	23·82	...	8·21	54°	19·0	167 12	This was the first trip with equal loads.
Dec. 1	Canute	Coal	2·39	29·16	20·22	13·48	8·07	150°	19·0	170 8	Great difficulty in starting; rails slippery in consequence of frost and damp fog; wind rather stiff against us.
,, 1	Vesuvius	Coke	2·47	27·92	24·92	...	7·78	54°	19·0	167 12	
,, 19	Canute	Coal	2·55	26·92	29·80	19·86	9·05	...	28·0	235 13	Frosty, with strong head wind against us.
,, 19	Vesuvius	Coke	3·09	24·71	30·16	..	7·13	36°	22·0	189 6	Water pipe in Canute gave way: shut off heating apparatus.

There yet remains the question of the durability of the fire-boxes and tubes when coal is used instead of coke; and I do not think that I could offer a better proof of the superiority of coal over coke in this respect also, than by quoting a portion of a report which I made on this important subject, on May 26, 1858, to the locomotive superintendent of the Manchester, Sheffield, and Lincolnshire Railway. The engines there referred to were built in accordance with Mr. Beattie's patent for burning coal and coke:

"With respect to the durability of the tubes and fire-boxes when coal is used instead of coke, I consider that question to be settled beyond dispute in favour of the former, inasmuch as it no longer remains a matter of opinion merely, but the result of continuous working with coal and coke demonstrates beyond all doubt that not only is coal superior to coke in respect to heating power, and consequently decidedly more economical, but it is less injurious to both the tubes and fire-boxes of locomotive engines; as a proof of this I beg to append a copy of a tabular statement which I had the honour of laying before the directors of the London and South Western Railway in the month of March 1856, showing the average duration of a set of tubes in their locomotive engines when coke alone was used. At that time as well as in the latter part of 1855, after I had made a series of experiments with coke and coal, I came to the conclusion that the tubes and fire-boxes would sustain less injury by the use of coal than coke, and although one of their coal engines had then run but 51,300 miles, and no really appreciable depreciation had taken place in either fire-box or tubes, I saw sufficient to warrant me in concluding that the life of a set of tubes as well as that of the fire-box would be considerably prolonged by the use of coal instead of coke. Time has proven that the opinion I then formed was a correct one, inasmuch as I have up to the present moment carefully watched the effects produced on the fire-boxes and tubes of the locomotive engines on the London and South Western Railway; and taking two of their engines which I have examined, where even part coke and part coal have been used up to the commencement of the present month, you will perceive the amazing difference in favour of coal when you compare the results with the tabulated statement in my printed report dated March 25, 1856. The average duration of a set of (coke engine) tubes was 94,518 miles; whilst in the two engines I have referred to where coal and coke have been used, one of them has run 154,955 miles, and is now carrying 120 lb. pressure of steam,—none of which tubes have failed, and they are still in good working condition, and I am unable to say how much longer they will last. The other engine has run 137,676 miles; and I have had two of her tubes sent to my office in Queen's-chambers, Manchester, which you can see at any time.

"I personally paid a visit to the works at Nine Elms and examined these engines; and bear in mind, that although a portion of the fuel used in these engines is coke, yet the tubes I now refer to have only worn to the extent of three wire guages in thickness; they were ordered and made to No. 13 wire guage, and are now No. 16 wire guage.

"No doubt exists in my mind that the principal portion of this amount of reduction in thickness is attributable to the cutting action of the coke, and not to the effect of any deterioration produced by the action of the coal. With regard to the effect on the fire-box of the latter engine, the back, sides, and crown are $\frac{1}{33}$ of an inch less than their original thickness, namely, $\frac{1}{2}$ an inch; the tube-plate has been reduced $\frac{1}{16}$ of an inch, the original thickness being $\frac{3}{4}$ of an inch. From these facts you will be able to draw your own conclusions—they speak for themselves—for in one case where coke alone was used, you have an average (taken from the company's books) of 94,518 miles as the life of a set of tubes, whilst in the other, where coke and coal are used on the same railway, and working similar trains, you have 154,955 miles run in the one case, and of 137,676 miles in the other, and the tubes still in good working condition.

"I have given you these facts as a sample of the results when coke and coal are used, because the fuel you are using in your engines is of a similar character; but I am prepared to prove that were your engines constructed to burn coal alone, the fire-boxes and tubes would be protected from the cutting action of the coke, and greater durability, much beyond the mileage I have reported for coke and coal, would be the result. I am not ignorant respecting the argument that some parties have advanced as to coal containing a greater amount of sulphur than coke; this is a fallacy which I had proved beyond doubt, and therefore I hesitate not to give you a strong opinion in favour of coal, for instead of its proving destructive to fire-boxes, tubes, or smoke-boxes, the result of my observations and experiments proves the contrary."

In further confirmation of the increased durability of the tubes,

Digitized by Google

I beg to state that the mileage of another engine of the same class as the two referred to, and burning a mixture of coke and coal, amounts to 181,589 miles, and the tubes are still in good condition, and working at a pressure of 120 pounds to the square inch.

In conclusion I beg to remark, that previous to the year 1853, several attempts had been made by different individuals to introduce coal as a substitute for coke in locomotive engines, but from various causes they did not persevere in developing its true commercial value, and I would take this opportunity of stating that the credit of this important saving in railway expenditure is due to the skill and persevering industry of Mr. Joseph Beattie.

Discussion.

The Secretary read the following communication, received from

Mr. D. K. CLARK.—I perfectly agree with Mr. Fothergill in assigning to Mr. Beattie the honourable position of pioneer in the successful practical introduction of coal as a substitute for coke in locomotive engines. I believe that from this source of economy alone an addition of nearly 1 per cent. may be made to the dividends on the original share capital of railways, taking one with the other, with the reduced wear and tear of locomotives. I think, however, that the mode adopted in the paper of illustrating the saving in cost effected by the substitution of coal for coke is open to criticism, and does not place the question on its proper basis. It is true that the quantity of coke manufactured from a given weight of coal weighs only two-thirds of the original coal so consumed, and that 1½ ton of coking coal make only one ton of coke. But in seeking to establish this ratio of 3 to 2 as the measure of saving, that is, that the cost of fuel is reduced one-third in dispensing with the coking process, it is overlooked that coking coal, as coal, is not the proper fuel for locomotives, and that therefore the calculation of saving should be based, not upon the relative quantities of coking coal and of coke made from it, but upon the relative prices and efficiency of proper locomotive coal and coke. This ratio is necessarily very variable, as it is affected by cost of transport and other elements. For instance, on one metropolitan line, whilst coking coal costs 12*s.* 6*d.* per ton, and the coke made from it costs 18*s.* 6*d.*, other coal suitable for locomotive uses costs as much as 15*s.* per ton. On another line, whilst the cost of coke is 23*s.* per ton, the coal suited for locomotives costs 20*s.* per ton, or only 13 per cent. less. Again, take the North Eastern Railway, at Newcastle, the difference of the cost of coke at from 8*s.* to 11*s.*, and locomotive coal at 7*s.* per ton, is so inconsiderable as to scarcely make it worth while to use coal on that line. Notwithstanding such local approximations in cost, there can be no doubt of the economical importance of the question before the meeting. Again, in the comparison of the coal-burning engines with the coke-burning engines of the South Western Railway, no allowance has been made for the benefit of heating the feed-water of the former, as against the use of cold water in the latter; whereas my own experience with Mr. Beattie's engine, the Canute, showed a most material increase in the consumption of coal when the feed-water was not heated. The following were the results I obtained from the engine with hot and cold water respectively:—

	Average train.		Coal consumed per mile.		Temperature of feed-water.
With heated water...	11 carriages	...	17·4 lb.	...	191 degrees
With cold water.....	11 ditto	...	24·0 lb.	...	56 ditto

Showing an increase of 6·6 lb. of coal per mile by using the feed-water cold, as was done in the coke-burning trials recorded by Mr. Fothergill. The coke value would therefore be 16 lb. per mile, and not 11 or 12 lb. as assumed in the paper, for comparison with the coke-burning engines. The large extra consumption of coal, by shutting off the heating apparatus, is no doubt greater in proportion than would be deducible from the known constituent heat of steam and water; but it is caused also by the less favourable working conditions of the engine involved in the use of cold water.

SIR JOHN RENNIE said that Mr. Fothergill proposed to establish that which appeared to be a very simple proposition, namely, that the whole was greater than its part; in other words, that coal, which contained all the elements of combustion and locomotive power, was more effectual than the same coal when deprived of some of its elements and converted into coke.

Mr. GRANTHAM said that the paper had disappointed him upon one or two points; Mr. Fothergill had not stated whether he employed the hot water apparatus in the coke-burning engines, as well as in those burning coal. He would also ask him whether he had considered the question of the blast in the coke and coal-burning engines, as he was of opinion that a much greater heat would be found in the smoke boxes of the latter than of the former, and less blast would therefore be required. That was an important point. Mr. Fothergill had stated that the wear and tear of the tubes of the boiler was very much less in the coal than in the coke-burning engines. That fully corresponded with his own experience; but there was another element to be considered, viz, the first cost of this particular description of engine. There might be a question whether the first cost of the engine, which appeared to be an expensive one, did more than make up for the difference in the wear and tear under the two systems. He did not say this with a view to depreciate the statements made in the paper, for he was an ardent admirer of the use of coal in locomotives. There was also another very important question, viz., the heat of the gases in the smoke box. He was afraid that railway engineers had overlooked this too much, and that those who had made experiments upon the subject had made some mistakes. He had lately taken pains to make inquiries of some of the leading engineers as to the heat in the smoke boxes of locomotives, and the answer he got generally was, that experiments had been tried, and that the temperature had been reduced as low as 300 deg. of heat; others had informed him that it was about 400 deg. of heat in the smoke box. A curious experiment had been tried in his own neighbourhood, where a thermometer had been let down into the smoke box, the bulb of the mercury going into the box for some distance, and the scale being in sight of the engineer. When the engine was standing at the station the thermometer recorded 300 degrees, but it had no sooner started than the thermometer fell to 150 degrees. This gave rise to some speculation as to the cause of this wonderful phenomenon, and many theories would, perhaps, have been founded upon it, but the whole was easily explained by the fact that round the thermometer there was a space, so that when the engine was put in motion, and the blast came into operation, the cold air struck upon the bulb of the thermometer, and lowered the temperature of the mercury. He believed the temperature of the fire-box would be much affected by the use of coal, and he was sorry that Mr. Fothergill had not brought that subject forward as an element in his experiments. Referring to specimens of spiral heat-diffusers before the meeting, Mr. Grantham explained that the glass tubes shown represented the tubes of a boiler, and contained a spiral bar of metal. This was the invention in the first instance of Mr. Duncan, who took out a patent for it. Mr. Charles Wye Williams, without being aware of these experiments, was making others in the most accurate manner of his own upon the same subject. Mr. Williams's apparatus was also patented, and as these patents clashed, and there were points in each desirable to be retained, they amalgamated, and the invention was now known as Duncan, Gwynne, and C. Wye Williams's Heat-diffusers. Mr. Grantham detailed the results of experiments made with the heat-diffusers as recorded by Gauntlett's pyrometer. The diffusers were placed in the tubes of the boiler, and he knew from experiment that they reduced the heat in the smoke box prodigiously, probably 200 or 400 degrees. The indication of the pyrometer with the heat-diffusers in was 800° in the smoke box, and he believed it would have risen to 1000 or 1200 degrees if the heat-diffusers had not been in use. He had every reason to suppose that if coke had been used in the engine instead of coal, the heat in the smoke box would have been less. If, therefore, Mr. Beattie's or any other coal-burning engine had this enormous temperature in the smoke box, it was evident that there was room for improvement in that respect, and it was another item in favour of coal if these deductions were correct. The heat-diffusers above alluded to promised very good results, the first trials showing nearly 20 per cent. of gain; and one of the practical difficulties in using them, viz., the supposed tendency in the tubes to become closed with ashes, had not arisen. For a great many years he had attended the experiments of Mr. Wye Williams, and had been a party to most of the investigations made by that gentleman upon the combustion of coal, and from the experience thus derived, he was of opinion that the operations so necessary in this matter would be carried on by a simpler engine than that of Mr. Beattie—combining, it might be, many of his contrivances, but doing away with a great deal that was complex.

Mr. JOHN BRAITHWAITE thought that ere long the boilers of engines would be constructed of a different form, so as to produce

Digitized by Google

more efficiently the draught in the furnace, not precisely after the plan which he (Mr. Braithwaite) brought forward in 1829, but such an improvement upon it that the combustion would be steadily carried on, and the gases essential to the generation of steam would be given out without the use of the diffuser to which allusion had been made. This principle had been carried out in the caloric engine, and had been found so far successful.

Mr. JOHN BETHELL said some years ago it was stated at the scientific institutions that the coke made from a certain quantity of coal would give the same amount of heat, and evaporate just as much water, as the coal from which it was made. He believed that was a theory advocated by Mr. George Lowe. He (Mr. Bethell) was astonished at that theory, for when they observed the great heat that was generated in converting coal into coke, it seemed very remarkable that the coke should, after being subjected to that process, give as much heat as the coal itself. The difference arose entirely in the mode of burning the fuel. It was possible, no doubt, to construct a furnace which would give coal no advantage over coke. The real point was the proper construction of the furnace. It was excessively simple to burn coke when operated upon by a strong draught, so as to get all the heat out of the carbon which it contained; but it was not so simple to burn coal, because this involved two operations; they had to burn the gases, which required one mode of treatment, and the carbon or coke, which required another mode of treatment. He had not yet seen any plan which, in his opinion, was perfect for burning all the gas and all the carbon. The plan laid before them that evening appeared to him very complicated. In France and Belgium, where they burnt a great deal of coal, as well as a patented fuel which contained more gas than coal, they had a simple apparatus for doing it, and they carried out the process in the locomotive engines without producing so much smoke as he had met with on railways in this country. It was a simple arrangement of the fire-box, which allowed air to pass in over the fire. With regard to the analyses before them, he could hardly believe them to be correct. It was easy to take an analysis of the composition of coal, but the ascertaining how much water a certain fuel would evaporate was a different matter, as apparatus specially adapted to the different kinds of fuel was necessary in order to obtain reliable results. If they were using an apparatus to burn coal which contained the gases as well as the carbon, they must have an apparatus in which the air came over the fire, and if the same apparatus was used for burning coke it would not answer. Hence they found it stated in the table before them that 1 lb. of Ramsay's coal evaporated 15 lb. of water, whereas 1 lb. of coke evaporated only 12 lb. of water. He believed if the coke were used with a proper apparatus it would evaporate more. Again, they found it stated that the Merthyr coal, which contained 89 per cent. of carbon and 4 per cent. of hydrogen, or 93 per cent. of heat-giving properties, evaporated only 14 lb. of water per lb. of coal; whilst Ramsay's coal, which contained only 90 per cent. of heat-giving properties, evaporated 15 lb. of water. That, to a theoretical man, seemed an absurdity, and showed that in all experiments as to using fuel for the evaporation of water, everything depended upon the manner in which the fuel was used. The Welsh coalowners had, for a long time, contended that their coal would evaporate a larger quantity of water than the Newcastle coal; latterly, however, the Newcastle gentlemen had asserted that their coal would evaporate more water than the Welsh coal: but, to his mind, such statements ought to have no weight, unless each description of coal was used with an apparatus especially suited for it. Then came the question whether the apparatus which was suitable for any particular description of coal could be practically adapted for general use with steam boilers. That was a matter of considerable difficulty. They could easily construct a small experimental apparatus, but they might not be able to apply it, when coal was burnt in masses for heating large boilers. He did not think the meeting was in a condition to argue this question upon the data given in the paper before them, or to enter into it in a way that its great importance deserved.

Mr. GEORGE LOWE, F.R.S., said, with reference to a statement which Mr. Bethell had noticed as having been made by him (Mr. Lowe) on the occasion of the reading of a paper upon this subject by Mr. Apsley Pellatt, that on that occasion he gave the general opinions of the books—of the schools—rather than his own. Mr. Pellatt's experiments upon the relative value of the coal and coke for the purposes of his immense manufactory had been of the most beautiful and satisfactory kind. Mr. Pellatt would work one week or a fortnight with coal, and the next with coke made from the same amount of coal, and he had shown that in every instance the work in his manufactory was done as well with the coke produced from a ton of coal as with the coal itself. There were eminent French chemists who confirmed Mr. Pellatt's views, which were further confirmed by some experiments made at Philadelphia; and it was to be remarked that whilst Mr. Pellatt was working upon a large scale, the French chemists on a small scale in a laboratory, and the Americans on another scale, and he (Mr. Lowe) was also making his own experiments, the results of all these trials seemed entirely to coincide. Some of the experiments recorded by Mr. Fothergill were made as far back as 1855; but the French engineers, during the last two years, had made immense progress in the successful introduction of coal into the locomotive engine. The great thing was how to conduct the combustion so as to make use of all the heat-giving properties contained in 1 lb of coal. Mr. Bethell had, no doubt, hit the point in stating, that it was absolutely necessary that a certain amount of air should go over the fire as well as through the furnace to produce the proper combustion of coal. The great object was to prevent smoke and produce heat. Many years ago his (Mr. Lowe's) father conducted one of the largest malting establishments in the country, and the whole of the heat in the kilns was produced by the bituminous coal of Derbyshire. All the products of combustion went through the kiln, and if any smoke had been produced, five minutes would have sufficed to destroy a very large quantity of malt. For the last thirty-five years there had not been a furnace erected by him in any part of the world in which the principle of letting a certain amount of atmospheric air pass over the surface had not been adopted.

Professor JOHN WILSON, F.R.S.E., referred to a point mentioned in Mr. Clarke's letter, in which that gentleman spoke of the difference between coal which was suitable for locomotive engines and that from which coke was made. He stated that the bituminous coals were not those best suited for these engines. If his (Professor Wilson's) idea was right, as to the value of fuel depending upon the amount of hydro-carbons it contained, then the more highly bituminous the coal was the greater would be its evaporative power. He could reconcile the difference in the relative quantities of sulphur in coal and coke in Mr. Fothergill's analyses, for when, as had been stated, it took $1\frac{1}{2}$ ton of coal to make a ton of coke, it was possible that an extra amount of sulphur might exist in the coke; but he could not understand how coal containing 2 per cent. of ash could be converted into coke containing 7 per cent. of ash, when only $1\frac{1}{2}$ parts of coal went to make one part of coke.

Mr. BETHELL thought he might have been misunderstood in his remarks in reference to the experiments on the relative heating powers of coal and coke. The point he desired to lay stress upon was, that he could not understand, and he could not believe, that if proper apparatus had been used for burning the coke, the evaporative power would have been so small in comparison with that produced by coal.

Mr. FOTHERGILL, in reply upon the discussion, said he had been entirely misapprehended by one or two gentlemen in reference to the analyses he had given. These analyses had been made in the laboratory of Mr. Dugald Campbell, and were not the result of actual experiment from the use of the fuel in a locomotive engine. With regard to the question of heating the feed-water referred to by Mr. Clarke in his letter, he would state that when experiments were first made with Mr. Beattie's engine that contrivance was not appended to it. The apparatus then used did not enable them to feed the boiler with hot water at starting, but as they proceeded on the journey the temperature of the water became higher; but in the modern contrivance they could commence the journey with the feed water at a high temperature. With regard to the relative quantities of the fuel, he had stated that $1\frac{1}{2}$ ton of coal had been used to produce 1 ton of coke; in some instances the quantity had been $1\frac{3}{4}$ ton of coal to produce 1 ton of coke; but in order that there might be no misunderstanding upon that point, he had put the calculation into the money shape, and he had stated what the result was without taking into consideration how much coal it required to produce a ton of coke, but had at once given the cost of working the train, which he thought was the legitimate question to which they should turn their attention. He took the coal furnished at a given price, and also the coke, and then instituted a comparison between the two, not

Digitized by Google

troubling himself about the different classes of coal and coke. He had conducted experiments for the Lancashire and Yorkshire, and the East Lancashire Railway Companies, but there was not time to apply the contrivance for heating the feed-water. With regard to the blast-pipe in Mr. Beattie's engines, they had had to increase the amount of air to soften the blast, for if they had a powerful blast, they then got an over-heated smoke-box. He never knew an instance of that upon the South Western line but once, which was during a heavy wind, where they had a powerful blast, and the whole of the steam was used in passing up the chimney.

THE NEW TOWN HALL, HALIFAX.

THE drawings for the new town hall at Halifax, prepared by Mr. Stevenson, the borough surveyor, have been exhibited in the present town hall during the past month. They are fourteen in number, and include two views of the principal elevation, together with the interiors of the Borough Court and Council Chamber. There are also three designs for the front towards Crossley-street, one with a dome attached, one without, and one without dome, but with a clock placed in a receptacle in the surmounting cornice. The style adopted is the Græco-Italian, the basement story being rusticated. In the lower story are four windows, circular-headed, and enriched with carved key-stones, marble shafts, &c. Each window is placed between two columns of the Doric order, slightly differing from the ancient examples. The principal entrance is in the centre of the front, and is boldly treated. A richly detailed string-course, with dentil moulding, divides this story from the one above. In this latter are five circular-headed windows, treated differently from those mentioned before. Their enrichments consist of marble shafts, carved capitals, and richly moulded architraves. Between each pillar are a couple of columns of the Corinthian order. The principle cornice is proportionately deep to harmonise with the scale of the elevation, and has ornamental carving occasionally introduced, while above, the line is broken by six pedestals, on which are placed a corresponding number of vases. The dome, as proposed, would consist of a tambour of plain masonry, upon which stands twelve Corinthian columns, placed in couples, having in each space a plain circular-headed window. From the cornice springs the semicircular dome itself, which is intended to be in stone, and to be terminated by an ornament in keeping with the rest of the design. The two other exposed fronts are comparatively simple, but that towards Broad-street has a four-column portico.

The accommodation provided for is as follows:—Upon the basement is a workshop for the plumbing department 75 feet long by 35 feet broad, and which faces Crossley-street. At the Broad-street end are the offices for the police, including a police parade, measuring 49 feet by 20. There are also cells (twelve in number), two day rooms, an inquiry water office, &c.

Upon the principal floor is a merchants' exchange, 52 feet by 28; a borough court, 51 feet by 28; rate offices, accountant's offices, residence for superintendent of police, magistrates' retiring room, warrant office, &c. The entrance corridor, with the grand staircase (placed beneath the dome), is also on this floor.

The other story is devoted to the council chamber (facing Crossley-street), and whose dimensions are 41 feet by 27 feet; also town clerk's offices, engineer's offices, mayor's parlour, committee rooms, &c. Both the interior of the council chamber and the borough court are designed in a style to harmonise with the exterior of the building. The estimated cost of the building is about £20,000.

THE ARCHITECTURAL EXHIBITION.

(CONCLUDING NOTICE.)

OUR concluding notice of the architectural works in the Conduit-street Galleries commences with

(203) Mr. T. Goodchild's "Front of Aldershott Market" ought to be mentioned, inasmuch as it is in course of erection, otherwise so insipid a design might well escape attention. Whether it can be classed under any particular style is a question; but we suppose it is intended for Palladian. The area of the market is stated at 11,000 super feet, and is L shaped on plan.

Several designs for the Chelsea Vestry Hall (about which there was so much discussion) find a place here, and thus invite comparison, more especially since that which obtained the first premium is among the number. This figures in our catalogue as (214), and is by Mr. W. W. Pocock, the finally successful competitor in the late competition for Mr. Spurgeon's tabernacle. The design before us shows a Classic façade, not servilely following any particular examples, but it is a specimen of the use that may be made of such by competent hands; being a really excellent composition. Another design, one of the three selected, is (210) by Messrs. Green and De Ville, and is also Italian, but appears to have too much of a chapel look for its purpose. There are no plans to explain the arrangements of either of these designs. But with the remaining one we are more fortunate, for Messrs. Godwin, besides their perspective view (212), send the sheet of three plans (213) to explain it. The ability shown in these plans is, it must be confessed, far greater than in the elevation, which is of that peculiar sort of nondescript Gothic that is novel without being at all successful, and in which it would be easy to point out flagrant breaches of even the principles of design and construction. The merit of the plans consists in their being so simple and straightforward. (209) is an Elizabethan design (very poor) for the same building, by Mr. Eyton.

More numerous than the designs around us submitted in the last-mentioned competition, are those for the Ellesmere Memorial, which here number no less than twelve sheets, and, as may be supposed, present a goodly array. Unfortunately, however, the quality is not equal to the quantity. Even the successful design (229), by Messrs. Driver and Webber, now in course of erection, though unquestionably the best we have seen, is not equal to some that have been called forth in connection with Crimean monuments. The place fittingly selected for this memorial is close to the stately family mansion, at Worsley, near Manchester, and its materials are Hollington stone and Derbyshire marble. It will not be necessary to particularise the design itself, as it has been recently made familiar to the public in more than one illustration. The other drawings are, it must be confessed, in the main undeserving of sober criticism; (215) for instance, is a specimen of that kind of bastard Gothic which is now all but exploded. It appears, however, to find especial favour in the eyes of Mr. P. Brannon, for we have seen the like from him before; and in this exhibition there are some ambitious flights of fancy in the same vein, in which the author pictured to himself an appropriate Trinity College Church, Edinburgh. (216), another design for the Ellesmere Monument, is equally absurd. We might well be spared such anomalies. (219) which is obeliskal, is also devoid of specific character; (220) is a strange combination of masses; (221) pseudo-Gothic with Scotch features engrafted; (224) an unwieldy tasteless affair, with which the little elegant design next to it (225) oddly contrasts, though the latter is too dwarfish, and does not altogether realise our conceptions. (226) A square campanile, is, in some respects good looking, but is inappropriate to the site; while (227) appears to us still less deserving, although it was "one of the eight selected designs which obtained honourable mention." (230), like some others, is based upon the Venetian Gothic; and, though heavily treated, looks more reasonable than many.

(232) A Crimean Memorial to the fallen of the 23rd Royal Welsh Fusileers, erected at Carmarthen, by Mr. E. Richardson, is a Gothic design, poor in its details. The inclosing railing has, however, more significance, military weapons being introduced in an effective manner by way of ornament.

For the "Trinity College Church, Edinburgh," we have several designs, some few accompanied by plans and brief explanations. These adjuncts (as we have repeatedly urged) are absolutely essential to the proper understanding of a design; it is therefore as much to the interest of the author as the examiner, that, to some extent at any rate, such clues should be given. In this, a professedly "architectural" exhibition, such omissions are inexcusable;—we are of course presuming that the fault of their non-appearance does not rest with the committee. (233) is by Messrs. Oliver and Lamb, and is one of the six which received special commendation. (234) is another elevation of the same, Gothic in style, and freely treated.

Mr. J. Nicholls, in (240, 241), has the exterior and interior views of his design, which was also one of the six selected, and it appears to be, on the whole, very well studied and carried out. The two succeeding drawings (242, 243) are by Mr. Dunn and Mr. Goldie. Both have founded their designs upon continental models, but the latter is by far the more successful. A plan and some sketches serve to elucidate it pretty clearly.

Digitized by Google

In both of Mr. Ellis's designs for the Cambridge Asylum (235, 236), the attempt at originality is more commendable than its realisation. The whole lacks spirit and character. Nor can more be said in reference to Messrs. Oliver and Lamb's "Attempt to improve the Ecclesiastical Architecture of Congregational Nonconformists," as exhibited in (245, 246). The plan consists of nave and aisles, under one span: the interior columns to be of iron, 10 inches in diameter, and the roofs constructed *double*, to meet the objection of extremes of heat and cold urged against Gothic open roofs. Another drawing (244) shows the authors' mode of introducing iron columns in tiers, to keep down the cost of roof timbers in buildings of large span.

Considering the number of designs sent in for "Heigham Church," it is a wonder that more have not found a place here. (248) appears to have nothing in its favour, unless there be merit in the plan, which does not accompany the view. Judging by the exterior, it is based on the *auditorium* principle, and the junction of the roof tells unfortunately on the general outline. Mr. J. H. Browne's design is shown in four drawings (249, 250, 272, 273); and looks better outside than in. The material indicated—red brick with stone dressings—would not be so suitable to the locality as the flint-work which is in that district almost universal.

The several designs for Mr. Spurgeon's New Tabernacle which are here re-exhibited, have been already commented upon when noticing the collection as a whole. The design for the Town Hall, &c. at Wokingham (259), submitted in a select competition by Mr. Fowler, jun., is cleverly planned to suit the site. The several frontages are also good;—their type, the ordinary Gothic of Northern Italy. "Upton-on-Severn National Schools" (262), erected from the designs of Mr. G. R. Clarke, have the merit of good taste combined with simplicity. The same gentleman has in (364) the New Toll-house erected at the Mythe, near Tewkesbury," a plain red brick building, with a convenient open timbered porch.

Mr. Mileham's "Competition design for the new Town-hall at Sutton Coldfield (264) is, as a composition, good, but is wanting in appropriateness of character. The author has made free use of continental details.

In (265 and 266) Messrs. Oliver and Lamb exhibit two poor designs for the Scarborough Sea-bathing Infirmary. In the plan however some good arrangements are noticeable, viz., the principal wards face the sea, and are open on all sides, the beds being only between the windows: the ventilation is natural and the warming by open fireplaces. Provision is made for 100 beds, and 1500 cubic feet are allowed to each patient in the wards. The estimated cost is between £5000 and £6000. Two other designs for the same building are in close proximity with these, but they do not claim especial mention.

The idea of a combination of materials with a view to produce ornamental effect has been tried in various ways, but it is, we believe, something novel to see metal crockets applied to stone, and the specimen in (270) does not quite reconcile us to its use. It shows a Caen stone chimney-piece with fittings complete. The crockets, &c. of polished brass, are fixed by means of screws and points in elastic cement filled into holes cut into the stone; —there are also dwarf columns of Serpentine, and recesses lined with tiles.

The Tottenham Church competition has produced drawings by Messrs. Knightley (274), Mumford (275), J. James (276), and F. G. Lee (277). Of these, the second mentioned is stated to be in course of erection; but a comparison of this with its neighbours only suggests a question as to the propriety of the decision. There is a peculiar barrenness of expression which alone would, one would have thought, been sufficient to condemn it. This cannot be said of either Mr. Knightley's design, (one of the six selected), or of Mr. James', both of which err to some extent in the opposite direction.

Competition designs for the proposed Schools and Residences at Forest Hill, are numbered (280, 283, 284, and 285), the latter by Mr. Messenger, is "about to be erected." Of the others, that by Mr. Eyton has an excellent outside arrangement, and that by Mr. Stapleton a good plan.

The "Parsonage house, Caversham," recently erected by Mr. A. Billing (286), is a very tame production, built of flint, with red brick dressings. A shade better is his "New Church about to be erected in Islington" (288), but it has a very common-place look. "Rosslyn Chapel" finds two delineators of its wild picturesque beauties,—(281) by Mr. A. G. Clayton, and (299) by Mr. P. Justyne. The latter is by far the best. In (298) Mr. Dobson exhibits a capital view of the "Interior of the Lady Chapel, Tynemouth Priory," as restored; and in (359, 360), two views, which are perfect gems in their way, of portions of the interior of the old Norman Castle at Newcastle-upon-Tyne.

The "Church lately erected at Dundee" (301), by Mr. H. E. Coe, is essentially English Gothic in its character, but there is sufficient evidence that its author is not over fettered by precedent. The bold staircase turret, which terminates pyramidally, and appears to balance the composition of the west end, may be cited as a happy idea. Of another department of our art—the domestic—we should be at a loss to point out a more consistent specimen than Mr. R. H. Shout's "Strangways Railway Arms Inn, Evershot, Dorset" (303). It is partially of half-timbered construction, and in execution looks better, we think, than in the drawing; which is a rare occurrence.

Mr. W. White's contributions are all of the same class,—plain, simple, and good, especially in their grouping. Italian Gothic appears to be still the source of most of his ideas; however, he contrives to clothe it with sufficient originality to entitle him to honourable mention on that account. He sends several drawings: —(118), "Milton Vicarage";—(297), "Winscott, North Devon," which has some relieving arches particularly well designed; and (316), a "Bank at St. Columb, Cornwall."

Mr. E. B. Lamb's style is too well known to need any description. An examination of his drawings this year induces us to repeat the opinion that, while everything he produces is distinguished by originality and talent, he is ordinarily more happy when following out a Palladian than a Gothic model. We need only compare (308), "The Working Men's Institute at Lower Norwood," with (323), "The new Market-house, &c. now erecting at Berkhampstead." (314), "Knotley House, Penshurst," is clever, but too much broken up by slight projections, corbellings, and dodgy excrescences, which, however ingenious, tend to disturb that dignity which buildings of magnitude should invariably possess.

Of Mr. Joseph James' "Spring-hill Cottage, Birmingham," we gave a bird's-eye view in a former number of this *Journal;* in (325)—a S.W. view—its well-studied detail is seen to advantage. Mr. W. P. Griffith pursues his application of natural types to ornamental architectural purposes, and in (321) shows the fruit of the evergreen oak converted into the purposes of the ordinary ball-flower. Mr. Heskett's two views of his "Design for the Schools and Soldiers' Institute at Chatham" (335,336), may be referred to as examples of simplicity combined with good taste, as we have had occasion to point out in others.

Mr. D. Brandon, sends some good Elizabethan designs. (332) is one of these, and shows "Taverham Hall, Norfolk," which is built of red brick relieved by white dressings. (354) is another such building—a "Manor House erected at Aylesbury." Mr. F. P. Cockerell, in (339 and 344), gives two of his beautiful gleanings from Venice; Mr. J. Drayton Wyatt sends an india-ink view of Pippbrook House, near Dorking, an old mansion enlarged and Gothicised by Mr. G. G. Scott; and Mr. Goldie (349) has a sheet of "Studies" in pen-and-ink, suggested by G. G. Scott's *Secular and Domestic Architecture.* These latter consist of a porch, greenhouse, window (with a balcony carried by corbelling shafts placed out of the upright!), interior of a room, shop front, and staircase; and they evince considerable ability. The next frame (350) consists of "Studies for Works in Progress," by the same gentleman, and is wholly devoted to ornamental details for various Roman Catholic works.

Mr. Edmeston sends two drawings—(173), a "Tomb now erecting in Highgate Cemetery," which is a great improvement upon the majority of such works. It is triangular on plan, each angle being masked by a full-length sculptured figure under a well-contrived niche, and the intermediate faces being filled in with panels in basso relievo. The covering to the whole is also of stone, pyramidal, and terminating in a handsome cross. The other drawing (351), is of two "Stone Porches, Canonbury-place, Islington," which are a kind of Italian, boldly handled.

The "Tower of Newport Church, Essex" (356), was rebuilt in 1858, from the remains of the former tower, by Mr. G. E. Pritchett. Its fine outline and commanding position render it an attractive object from the Eastern Counties Railway; the present drawing fails to do it justice.

Messrs. Finch, Hill, and Paraire send (357) an external view of the "Britannia Theatre, Hoxton," recently erected by them. Being to a great extent inclosed by dwellings, one would not

Digitized by Google

readily divine its purpose from this drawing: the architecture is of very questionable taste and the ornament trashy. The interior (of which a view is to be seen in the Royal Academy) is a much more favourable specimen.

The two most important drawings of their kind in the exhibition are (328 and 329), in which Mr. Goodchild has most ably given interior views of "Sir Christopher Wren's first design for St. Paul's Cathedral," from the model now in the Kensington Museum. One of the views is taken directly under the dome, and the other is taken in the nave. These drawings are to a large scale, carefully outlined, and tinted in sepia in a very masterly manner.

Other important drawings—one of them the largest in the room—are by Mr. Pennethorne, who, in (291 and 292) shows the two principal façades of his "Design for the new Government Offices,"—one being towards St. James'-park, and the other towards Parliament-street. This latter would be 600 feet long, and occupy the whole area between Downing-street and Great George-street. It is of Italian character. The lines of frontage are but little broken, perhaps not sufficiently so, the author having aimed apparently rather at a grandeur in the whole mass than completeness in detached portions. These drawings are very carefully executed, but would bear more making out in the expression of many of the features.

Mr. S. S. Teulon exhibits but one drawing (293),—"The almshouse and chapel erected by him at South Weald, Essex," a good specimen of brick design, and in which a great inequality in the levels of the ground has been turned to due advantage in a picturesque point of view. The buildings are actually close to the road-side, but here are shown as if in a spacious plantation. In the same frame is a view of some schools built in similar style in the same village; also a design for restoring the church, which it may be remembered is in a most lovely situation, and whose south door is one of the most curious and perfect examples of Norman work existing. (It was published, we believe, by Britton.)

Mr. Owen Jones contributes a highly coloured drawing (358) of the "Ceiling decorations of St. James' Hall," developed so as to show the exact outline of its pattern, which is painted in white on a blue ground, with excellent effect. — "Christ's Hospital, Sherburn," near Durham, by Mr. Austen, provides for thirty-five inmates, the comfort of whom appears to have been praiseworthily consulted. The fall of the ground gives room for a covered promenade open to the south, and fitted with benches against the walls, between the centre wing and the kitchens. The warming is effected by open fire-places, assisted in the corridors by the hot-water apparatus. All the flues are formed of combined smoke and air flues, the latter communicating with each room near the ceiling. The walls of the new building are constructed of "Snecked rubble," with Ashlar dressings to windows, &c. The roofs are covered with blue Welsh slates.

Messrs. Vulliamy and Johnson, in (337), have a very effective exterior of the proposed church at Rochester. It is thoroughly Gothic in its conception, and very well proportioned. A lofty tower and spire are prominent objects; the latter has spire lights immediately above the parapet, but above is totally devoid of any kind of enrichment whatever, and compared with the rest of the building it has a very bare look. (334) Mr. Goldie's "Design for Memorial Altar and Reredos at St. Vincent's Roman Catholic Church, Cork," is highly elaborated. Ornament of every kind is lavished by means of sculpture, marbles, and inlay work. There is a very well designed metal cresting running above the principal cornice.

A few photographs which we have not mentioned are deserving of notice. Two of the "Additions to Hampton Lucy Church, Warwickshire," are given in (385 and 390), the former showing the very rich and beautiful apse externally, and the latter an equally handsome reredos and arcade which surrounds its wall internally. The original church was erected from the design of the celebrated Rickman. It cost a large sum, and was considered among his best works, though very different from such as we are now accustomed to rear. The carving to the new additions, which is of the most ornate description, has been executed by Mr. Philip, who in (391) has a very perfect photograph of "The upper part of the column erected at Melbourne, in memory of the late Sir C. Hotham, Governor of Australia," of which a full account has already appeared in our pages. Other photographs exhibited are—(381, 382) two views, by Mr. Brakspeare, of "Great Lever Church, Lancashire;" and (384) is a tasteful monument erected in the Mauritius, the workmanship being by Mr. Cundy of South Lambeth.

A rather extensive collection of designs for stained glass (principally the full size cartoons) is dispersed in various parts of the galleries, and includes specimens from most of our best artists. (5) is Messrs. Ward and Hughes' design for the large "West Window of Glenalmond College, Perth;" and (395) is the West Window of All Souls' Church, Halifax." There are also several of a series of "Crimean Memorial Windows" designed for Harrow School chapel by Mr. Powell, of Messrs. Hardman's establishment, and exhibiting considerable talent. Messrs. Hardman and Co. have also a design for part of a "Crimean monument at Eton," and part of a "Window executed for Carlisle." Messrs. Clayton and Bell send some beautiful cartoons for the stained glass they are now preparing for "St. Michael's, Cornhill;" also "One of a series of Lancet Windows, now executing for the North Transept of Westminster Abbey." Messrs. Lavers and Barraud show the "East Window of Upper Tooting Church," which illustrates the "Te Deum;" also some full size cartoons for churches in Cornwall and Sussex. Several interesting studies of the same class, from the celebrated Cathedral of Chartres, are exhibited by Mr. J. J. Laing, who also sends one or two "designs for stained glass medallions." There are not this year any frames of the actual material, glazed up, such as we have seen in some former exhibitions, and it is difficult to pronounce opinions as to real results from an inspection of the mere preliminary cartoons; we therefore reserve any decided expression on these subjects till we have had other opportunities of forming our judgment on them.

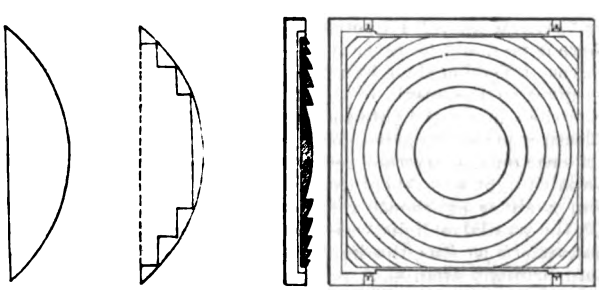
It remains to add, that the attendance on the occasion of the several architectural lectures this year was, as heretofore, highly encouraging;—that the exhibition is now opened on Tuesday *evenings* also;—and that it will finally close on the 30th inst.

REVIEW.

Lighthouse Illumination; being a Description of the Holophotal System. By THOMAS STEVENSON, F.R.S.E.—London: J. Weale. 1859. 8vo. pp. 122.

The most characteristic modern improvement of the optical apparatus of lighthouses, consists in refracting the light by means of annular zones of glass built up together to form a composite lens. It may very easily be seen that the effects of a common lens to concentrate or disperse light will in many cases be unaffected by cutting away a large part of the material of the lens. For instance, if parallel rays are incident perpendicularly on the plane surface of the plano-convex lens (Fig. 1), they will suffer no refraction at that surface, and their refraction depends solely on the curvature of the convex surface: it is clear that they will be similarly refracted by the lens Fig. 2, of which the anterior surface has the same curvature as that of Fig. 1, and the posterior surface presents a number of annular planes, so that the light enters the lens perpendicularly as in the former case. It is clear

FIG. 1. FIG. 2. FIG. 3.



also that the optical effects of the lens Fig. 2 will not be altered by arranging its several parts so that the planes last mentioned lie all in the plane represented by the dotted line. In this case the lens assumes the form Fig. 3. This annular lens is a most important part of the modern system of lighthouses. The idea of such a lens originated before Fresnel's time, and was suggested in various forms by Buffon, Condorcet, and Sir David Brewster; but the first actual construction of such lenses for the purposes of lighthouses is due to Fresnel. The great merits of these lenses are that they are capable of being made up of several pieces;

Digitized by Google

that not being so thick as ordinary lenses they absorb less light; and that as the several component zones may be ground to different curvatures, the aberration due to a common spherical lens is in a great measure corrected.

Mr. Thomas Stevenson, who has been the engineer of many important lighthouses, has carried the improvements of the optical apparatus of lighthouses beyond the point where Fresnel left them, and in the work before us records various practical applications of optical principles to the economy of light. It is no mean merit to have advanced beyond so illustrious a predecessor as Fresnel, but we conclude the perusal of the clear and interesting account before us with the conviction that modern engineers of lighthouses—and Mr. Stevenson pre-eminently among them—have succeeded in several important particulars in improving and extending Fresnel's method.

The improvements here referred to relate solely to the optical apparatus; the improvements of the light and of the construction of the building are not within the scope of the present treatise. What it designates the "Holophotal System" is a number of contrivances having for their object the economy of light. As these contrivances are various, the word "system" does not appear applicable to them; and the word "holophotal" seems rather to describe that which is the plain *duty* of the engineer—the economical distribution of the light—than to any one optical principal or method of illumination

The principal improvements here described are of two kinds,—improvement of the material of the apparatus, and improvement in the disposition of its parts. The former head comprehends the substitution of totally reflecting prisms for metal reflectors; the latter, various improvements of the forms of Fresnel's lenses, and combinations of them with reflectors for the purpose of advantageously directing light in the directions which the exigencies of the mariner require. The principles on which these improvements depend do not require for their comprehension a profound knowledge of the laws of optics. On the contrary, all the material parts of the work before us would be perfectly intelligible to a person barely acquainted with the elements of the science, and who brought to the reading no more knowledge than a rough notion of the laws of refraction and reflection, and the aid of a fair stock of what for want of a better phrase we must call the *common sense* of the subject.

The principle of "total internal" reflection, which is one of those made use of in the improvements here described, consists simply in this—that light incident very obliquely on the surface of a transparent medium will be reflected from it instead of entering it; much in the same way as a stone striking the surface of water very obliquely glances from it instead of entering it. By reflection from metallic reflectors a large proportion of the light (amounting to a quantity between one third and one half) is lost; whereas the loss of light by internal reflection is inconsiderable. Indeed, this species of reflection is termed *total* reflection on the supposition that no light is lost by it; but we apprehend that in practice this is not strictly the case, as the surfaces from which the light is reflected are not mathematical planes, but have unavoidable irregularities; so that the whole of the light is not incident at the same angle, and where the angle is greater than the "critical angle," refraction instead of reflection takes place. There is no doubt however that the loss of light is much less by internal reflection than by reflection from specula. Mr. Stevenson gives as the result of 31 trials, by four different observers, upon the amount of light available after passing through a totally reflecting prism prepared for lighthouse purposes (the angle of incidence on the external refracting surface being 39°), that the available light was ·805 of the incident light. But after reflection from a silver lighthouse reflector, the angle of incidence being 45°, the available light was only ·556 of the incident light; so that, *cæteris paribus*, the light reflected on the former system is more brilliant than that reflected on the latter system in the ratio of 16 to 11.

Fig. 4.

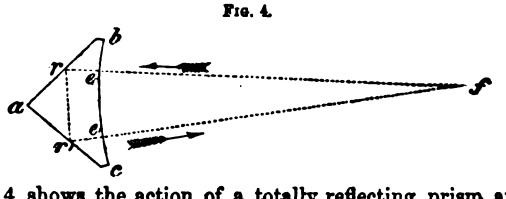
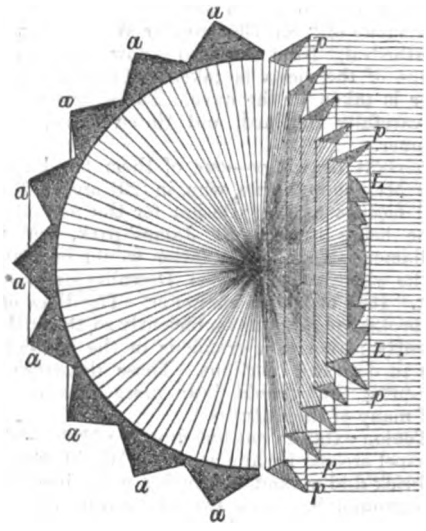


Fig. 4 shows the action of a totally reflecting prism applied to the back of the lighthouse, to reflect the light forward through the flame from which it emanates: *f* being the flame, *bc* a spherical surface of which *f* is the centre, and *r*, *r'*, points at which total reflection takes place. An application of these prisms is shown in Fig. 5, which is one of the holophotal arrangements proposed

Fig. 5.

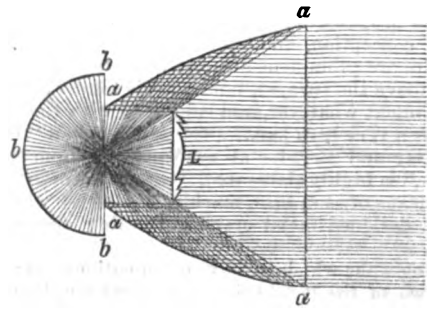


by Mr. Stevenson. In this arrangement the light incident on the reflecting prisms *a*, *a*, *a*, at the back of the lighthouse, is thrown forward through the flame, and then with the rest of the light diverging from it passes partly through the annular lens L, L, and partly through the prisms *p*, *p*, *p*, *p*, in a state of parallelism. With respect to the last-mentioned prisms it will be observed that they produce only one internal reflection, whereas those at the back of the apparatus produce two.

It does not appear however that this instrument has ever been used in practice. We imagine that the cost of its construction would be very great, and Mr. Stevenson states that the instrument would have been completed "but for the difficulty in the present state of the manufacture of flint glass of procuring castings of sufficient size and purity, it being essential to the action of the instrument to employ flint glass, or some other glass of high refractive power."

Another of the holophotal arrangements, less costly, but subject to the loss of light due to metallic reflection, is shown in Fig. 6. The object, as in the last-mentioned arrangement, is to throw the whole of the light forward in a state of parallelism. This is effected by the combination of an annular lens L, a trun-

Fig. 6.



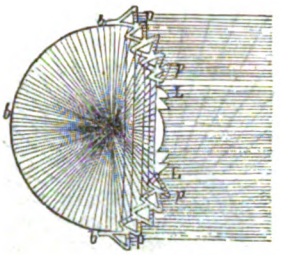
cated parabolic reflector *a*, and a spherical mirror *b*. The latter reflects the light incident on it back through the flame, whence it diverges with the rest of the light,—and part of the diverging rays are transmitted in a state of parallelism by the refractor L, and part are reflected in a state of parallelism by the reflector *a*.

In this arrangement there is the loss due to metallic reflection, but a sort of compromise between the two methods just described has been invented by Mr. Stevenson, and applied by him to the Horsburgh light, near Singapore. This light (Fig. 7) has the spherical mirror for reflecting the posterior rays of the Fresnel lens, parallelising a portion of the diverging beam, but for the parabolic mirror last mentioned are substituted the prisms *p*, *p*, *p*, *p*. These prisms act in the same way as the prisms *p*, *p*, *p*, *p*, of Fig. 5;

Digitized by Google

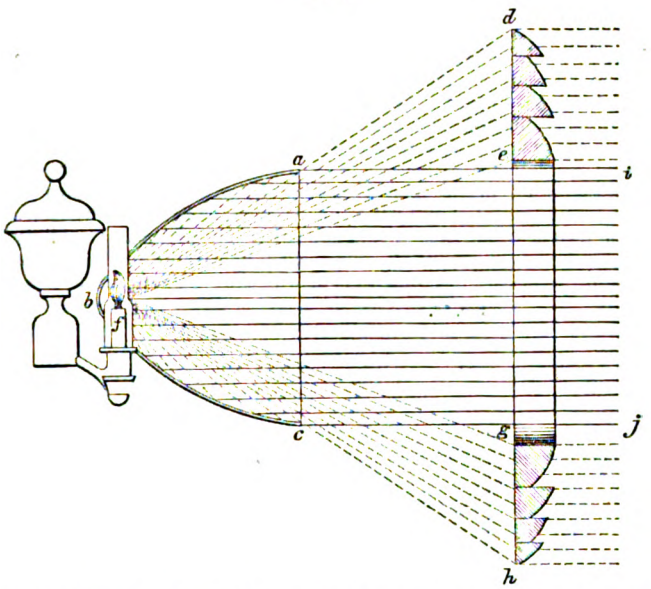
that is, they are partly refracting and partly reflecting. These prisms Mr. Stevenson, apparently on good grounds, claims to be his own invention; but he states (in a note, p. 31) that there are other claimants of it.

Fig. 7.



The contrivances for the purpose of throwing forward in one beam of parallel rays the whole body of light emanating from a flame are very numerous. The work before us describes an invention for the purpose by Fresnel, and which consists of a combination of lenses and plane reflectors; also a reflector invented by M. Bordier Marcet in 1819; another, invented by Mr. Barlow in 1837; and lastly, the invention of Mr. A. Gordon, C.E., described by him in this Journal for 1847 (vol. x., p. 385). This invention is shown in Fig. 8: it consists of a parabolic mirror *abc*, with the flame *f*

Fig. 8.



in the focus, having in front some of the outer refracting rings of Fresnel's lens *degh*. It will be observed however that the diverging rays of the cone having the vertical angle *efg* are not parallelised. Now apparently this is a larger portion of the light of the lamp than the portion incident on the parabolic reflector in front of the flame; but it is in order to parallelise the latter portion that the aperture *eg* is left. It seems therefore clear that there would be gain of light by filling up the aperture with a lens in order to parallelise the former portion, and by suffering the latter or smaller portion to diverge. But if we remove the parabolic reflector in front of the flame, there remains nothing of the invention except the reflector behind the flame, which from its small size is probably very ineffective.

The work before us describes two methods of applying the holophotal system to revolving lights, and compares them with Fresnel's method for the same purpose. The three methods are shown in Figs. 9, 10, and 11. In the first of these parabolic reflectors, R, R, are used, similar in principle to those of Fig. 6, and combined as in that case with an annular lens. In the second method for revolving lights (Fig. 10) the metallic reflectors are dispensed with, and in their place are the partly reflecting partly refracting prisms which we have already described. This apparatus was constructed for the lighthouse of North Ronaldshay, and completed in 1854. Lastly, Fig. 11 represents Fresnel's revolving light, constructed with the latest improvements, for the great light of Skerryvore, and lighted in 1844. In this light, L, L are the lenses which parallelise the central portion of the light, and *a* and *b* are the compound arrangement of lenses and plane reflectors already adverted to for intercepting the rays above the lenses L, L.

Fig. 9.

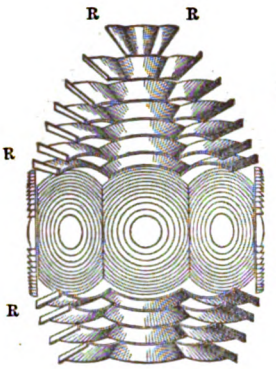
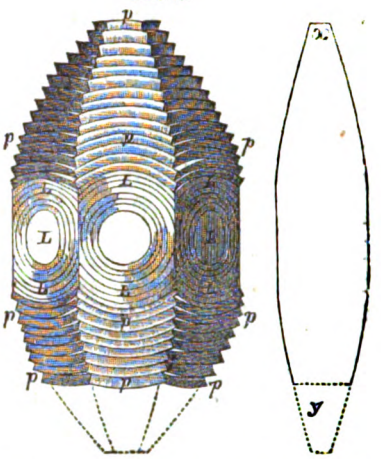
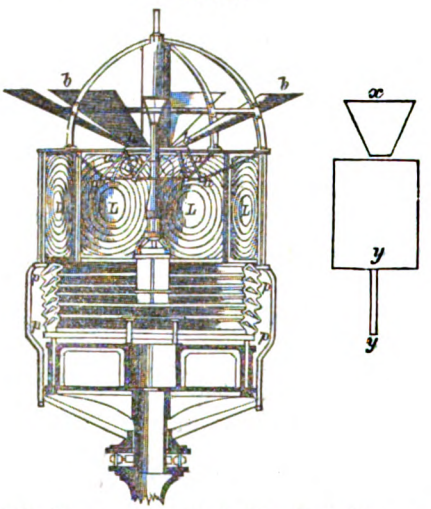


Fig. 10.



In comparing the holophotal method, Fig. 10, with the method of Fresnel, Fig. 11, Mr. Stevenson remarks that in the former the light is parallelised by a single agent where in the latter two are required; moreover the latter is subject to the loss of light due to metallic reflection; and M. A. Fresnel himself, with respect to the latter, estimates that the incident light is reduced to one-half in its passage through the apparatus.

Fig. 11.



In each of the three systems the light collected in as many beams of parallel rays as the polygonal apparatus has sides; so that if the polygon revolves once in a minute, there will be the same number of flashes of light in a minute succeeded by intervals of darkness.

Among the numerous variations of lighthouse lights described in the work under review, one of the most interesting is that consisting of a *fixed light varied by flashes*. This kind of light is the invention of M. Augustin Fresnel, but the mode in which he produces it is entirely different from Mr. Stevenson's. M. Fresnel surrounds the light by a fixed light apparatus as shown in Fig. 12, so that all the rays are brought into a horizontal direction, but *radiate in every such direction equally*. In order to produce the flashes he places outside the apparatus straight prisms *p'p'*, which revolve round it. Now it is a well-known principle of optics that the effect upon light passing through two prisms, one of which is horizontal and the other vertical, is similar to that of a lens; for the one prism collects the light horizontally, and the other collects it vertically, so that the two together produce actual *condensation*. (We are here speaking in rather loose

Digitized by Google

language, as our object is merely to give a popular explanation of the subject.) Thus, in the apparatus Fig. 12, the fixed annuli effect the purpose of horizontal prisms, by bringing all the light into a horizontal direction, and the revolving vertical prisms complete the condensation wherever they act, by deflecting the light in the horizontal or azimuthal planes.

Mr. Stevenson effects the same object by a very different and very elegant method, which is shown in Fig. 13. He surrounds

Fig. 12.

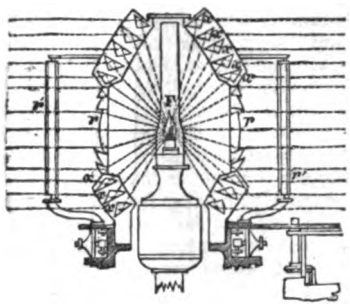
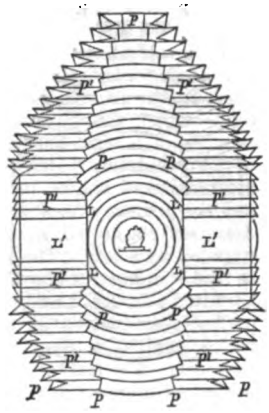


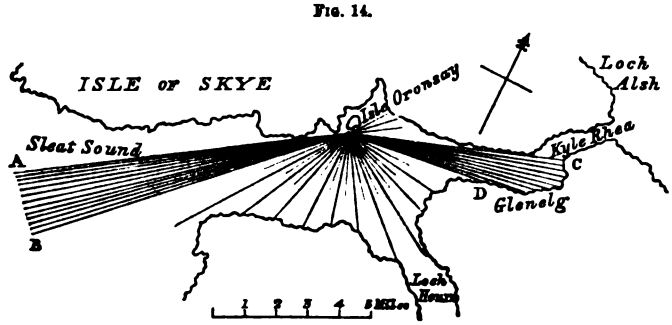
Fig. 13.



the light by a polygon, of which the sides alternately consist of cylindrical annuli $p'L'p'$, and spherical lenses and parts of lenses pLp. The former merely bring the light into the horizontal direction: the latter collect the light into beams. In both kinds of apparatus the characteristics of a fixed and a revolving light are given, the light being at regular recurring intervals bright and feeble.

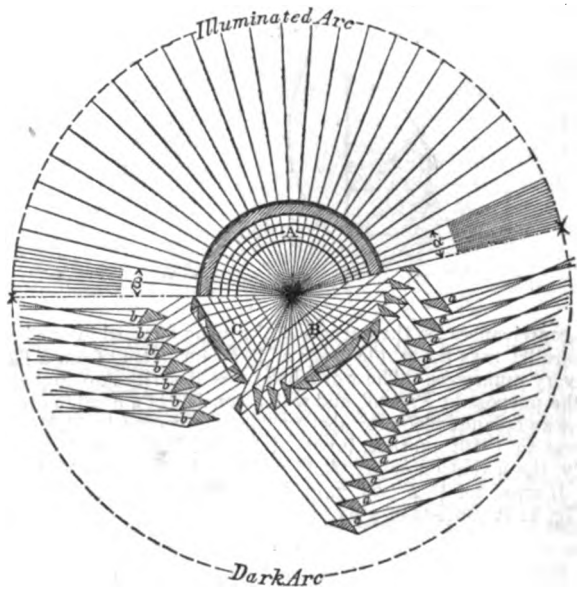
There are many ingenious contrivances in the work before us for varying the direction of light, which we are unable to notice for want of space. The following however may be adverted to, on account of its intrinsic interest, and because it has been practically applied to a work of great importance. The Oronsay Lighthouse, which was publicly lighted in 1857, was required to fulfil certain conditions depending on local circumstances. The lighthouse is situated in the narrow Sound of Skye (Fig. 14), and

Fig. 14.



was required to cast a bright beam of light AB, down the Sound, and another bright beam DC, up the Sound; and likewise to illuminate, but less brilliantly, the intermediate arc BD. The arc next the Isle of Skye was not required to be illuminated. In order to satisfy these exigencies, the method represented in Fig. 15 was resorted to by Messrs. Stevenson, and carried out by Mr. James Balfour, who also made the necessary drawings and calculations. The one bright beam was obtained from the posterior rays parallelised by the lens B, and subsequently deflected by the prisms *a*. The other beam was similarly obtained from posterior rays parallelised by the lens C, and subsequently deflected by the prisms *b*. The illumination of the remainder of the illuminated arc was obtained by suffering the remainder of the rays to fall on the Fresnel's lens A, from which they radiated horizontally. The apparatus seems to have been entirely successful, but we should imagine must have been costly from the number and complication of its parts. As there must be many situations in which it is requisite to direct beams in fixed directions, we venture to suggest that the principle of Mr. Stevenson's own invention, Fig. 10, may be applicable in such cases. That invention was designed for revolving lights, but the apparatus when not revolving collects portions of the light into beams

Fig. 15.



having fixed directions. If as in Fig. 16 the lenses B and C were employed to direct the beams in the required directions, and the arc A were occupied by a Fresnel's apparatus for radiating the light horizontally, the posterior rays being reflected by the spherical reflector D, it seems to us that all the conditions of the problem would be satisfied. It is true that by the employment of a metallic reflector there is a loss of light, but there must be also a considerable loss by the rays passing, as in Mr. Stevenson's plan, first through lenses and then through prisms. Certainly the method here proposed is simple, though we admit that there may be practical objections to it of which we are ignorant.

Fig. 16.

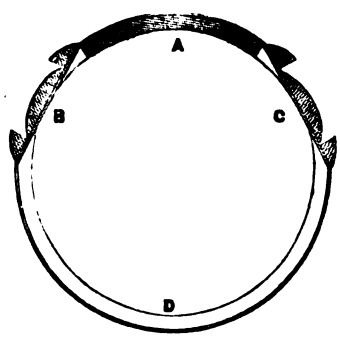
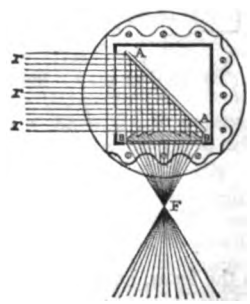


Fig. 17.



Another remarkable contrivance of Mr. Stevenson is the *apparent* light or beacon erected by him in the bay of Stornaway. The beacon was required to be situated at a point (Arnish Rock) on which, on account of its inaccessibility, a light could not be kept burning. The manner of overcoming this difficulty was the erection on the rock of a beacon which *reflects* a beam of light, of which the source is a lighthouse on the adjacent coast, 530 feet distant. Fig. 17 shows the plan of the beacon. The rays of light are directed from the lighthouse in a beam of parallel rays *r*, *r*, upon a plane mirror A, A, and after reflection are refracted by the prisms B, B, and diverge at the required angle from F. Mr. Stevenson remarks that in the case of this beacon it would have been difficult to have substituted totally reflecting prisms for the plane reflector, as the rays were required to be deflected through so large an angle that such prisms could not have been employed unless made of glass having a high refractive index. A plan is suggested by Mr. Stevenson, Fig. 18, for an apparent light capable of illuminating half a circle. In this plan the rays are incident on a plane mirror *p*, *p*, thence pass through the totally reflecting prisms B, and thence emerge through the outer pane of glass of the beacon. This pane is

Digitized by Google

semicircular in plan to avoid loss of light, which would be occasioned by the oblique incidence of the emergent rays upon it.

FIG. 18.

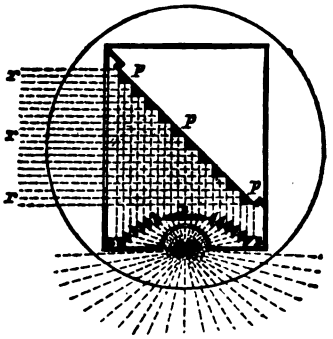
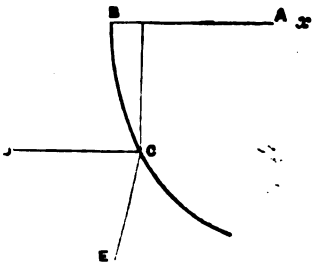


FIG. 19.



It seems to us that illumination of half a circle by the apparent light might be obtained by a single agent, namely, a cylindrical convex reflector, instead of p, p. From such a reflector the rays would be reflected so as to illuminate a semicircle without the aid of the prisms B. In ordes that the illumination might be equally bright in every part of that semicircle, the horizontal section of the reflector should be a proper curve, which can be easily obtained by analysis.

Let BC be a horizontal section of the reflector, and the direction of the illuminating rays be parallel to BA. Let the ray DC be reflected in the direction CE. Then, since the angle of incidence is equal to the angle of reflection, if the normal through C be inclined to AB at the angle θ, the angle DCE$=2\theta$. Since the dimensions of the beacon are inconsiderable compared with the distance of the horizon, all the reflected rays incident on BC may be considered to illuminate an arc of the horizon which subtends an angle 2θ, and has its centre anywhere in the beacon.

Let B be the origin of co-ordinates, BA the axis of x, and the perpendicular on this axis from C$=y$. In order that equal portions of the illuminating beam may illuminate equal arcs of the horizon, y which is the breadth of the portion of the beam incident on BC, must be proportional to the arc illuminated by it, and therefore to θ. Consequently $ay=\theta$, where a is a constant determined as follows: Let h be the total breadth of the illuminating beam, and α the greatest value of θ. Then the total arc illuminated subtends an angle 2α, and therefore by the last equation $ah=2\alpha$, which gives the value of a.

By the geometry $\tan\theta=\frac{dx}{dy}$. Therefore $\tan ay=\frac{dx}{dy}$. Integrating, and making x zero when y is zero, we get $\cos ay=e^{-ax}$ for the equation to the required curve.

We regret that we have not space to describe more of the ingenious contrivances which are mentioned in the book before us. We believe that many of its subjects have been already discussed in previous treatises by Messrs. Stevenson, but the present work, besides being a summary account of established modern improvements of lighthouses, is valuable as a lucid and clear exposition of the more recent modifications of the author's valuable system of illumination.

EXHIBITION OF INVENTIONS AT THE SOCIETY OF ARTS.

THE Eleventh Annual Exhibition of Inventions collected in the rooms of the Society of Arts is not equal to several of its predecessors, in the novelty, utility, and importance of the objects exhibited. Several of them, instead of being the inventions of the past year, have seen many summers, and the introduction of even a few known old inventions throws doubt on the novelty of the remainder. Assuming however that, if not actually new, they are now for the first time exhibited publicly, we shall proceed to notice those mechanisms and contrivances that claim attention either by their ingenuity or by the usefulness and importance of the objects they are intended to effect.

A large portion of the space of the exhibition is, as usual, allotted to railway mechanism; commencing with coal-burning locomotive boilers, safety-valves, railway chairs, brakes, buffers, and new systems of railway signals. We do not, however, observe a single model of a contrivance for making communications between railway passengers and guards, and between the latter and engine-drivers, of which class of inventions there is usually a fruitful crop in mechanical exhibitions. It may be that inventors are tired out by the obstinate perseverance with which railway directors refuse to adopt such contrivances, though the want of communication is daily more and more experienced.

The contrivances for burning coal in locomotive boilers have all of them the same object as the smoke-consuming furnaces; but, however effectually they may succeed in preventing the intolerable nuisance of the emission of volumes of black smoke from the chimneys of locomotives as they are propelled along the green valleys and past rural habitations, yet they do not prevent the sulphurous exhalations and the pouring forth of carbonic oxide, which, though invisible, are a serious annoyance to the passengers. The coal-burning locomotive boiler of Mr. Brotherhood, of Chippenham, which is the first in the catalogue, effects the combustion of smoke by the interposition between the fire-box and the ordinary flues or tubes of what he terms a "combustion-chamber" connected to the fire-box by one or more tubes surrounded by water. The heated gases in passing from the furnace to the combustion-chamber are exposed to atmospheric air, admitted through a number of small tubes; and to effect a more perfect combination of the air and heated gases, they are impelled against a disc of heated fire-clay in the combustion-chamber. The mixture of atmospheric air with the heated gases is effected more simply by Mr. Ashton, of Birkenhead (No. 2), by a deflecting plate fixed inside the fire-box to deflect the air entering by the door downwards among the gases while yet in the furnace.

Messrs. Duncan and Gwynne exhibit spiral heat-diffusers (No 5), which consist of twisted plates of metal to be introduced into the tubes of steam-boilers, the object of which is, as stated in the catalogue, to "arrest a large measure of heat, transmit it to the water, and convert into working steam that equivalent which without these appliances would escape through the flues and be lost." The filling the space of the tubee with these twisted plates must necessarily retard the passage of the air, which seems to be its object, and thus diminish the draft, therefore it can scarcely be practicable to introduce them into boilers at present in use, but practical engineers speak of them as a valuable improvement.

Picking's boiler-feeder (No. 4) is another contrivance connected with steam-boilers, but it does not seem practically applicable. There are numerous inventions for feeding boilers and keeping them at the proper water level, which propose to do it more simply than by this arrangement, which involves the construction of a separate strong iron vessel, with a combination of pipes and valves and floats that seem superfluous.

A more useful, though very simple, invention is the woollen felt for covering steam-boilers (No. 6), patented by Messrs. Garnett, of Otley, Yorkshire. It is composed entirely of waste woollen refuse from paper mills, which is converted into a coarse pulp by the ordinary rag engine used in paper making, and when felted by heating it becomes solid. This material, which ought to be very cheap, is represented to be so excellent a non-conductor of heat, that, when applied to a high-pressure boiler, candles may be laid upon it for weeks without melting.

Of safety-valves and pressure gauges there is a fair proportion, though none of the former possess such special merit as to deserve notice. So little encouragement, indeed, is given by engineers to the improvement of the safety-valve that it is only surprising any such attempts should be made. As an example how little attention is paid to this subject, we may mention that some time ago a new kind of safety-valve was shown to one of our most eminent engineers, which he admitted would fully answer, and could not fail to act in all circumstances; but, he observed, "It's of no use; the present safety-valve answers all purposes." Notwithstanding this dictum, steam-boiler explosions of the most fearful kind are frequently occurring, which an effective safety-valve would prevent.

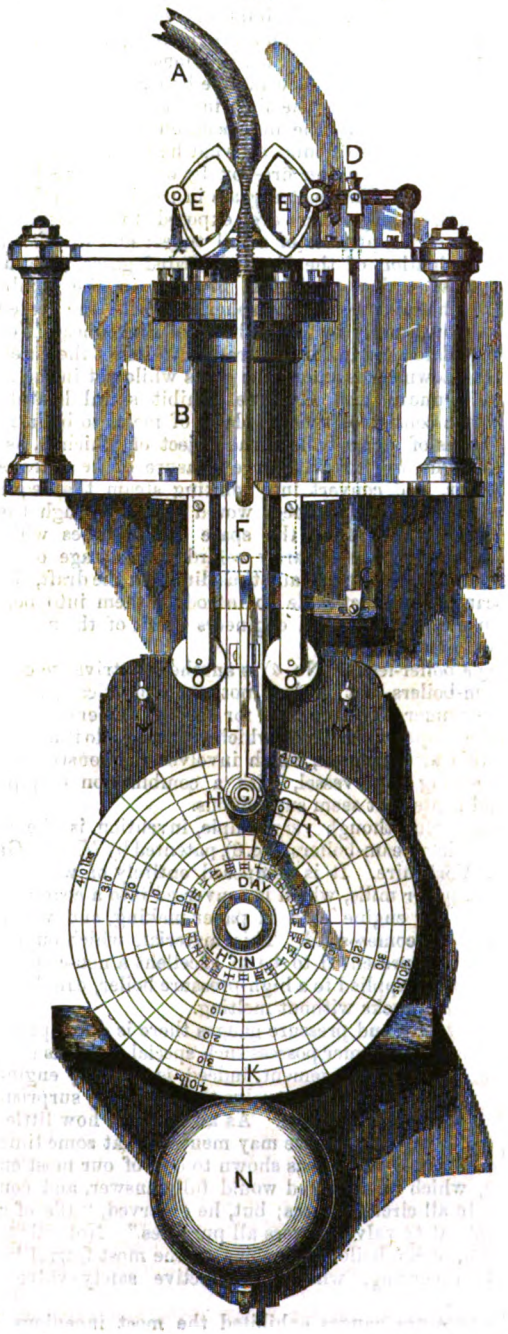
Of the pressure gauges exhibited the most ingenious, but at the same time the most complicated, is that of Mr. Mann (No. 15). The steam is admitted to a spring piston working on a small cylinder, and to the piston-rod is attached a pencil that is maintained in a vertical position by guides. The piston of course rises or falls according to the pressure, and it communicates the same movements to the pencil, which is pressed against a vertical paper disc. The disc is caused to rotate once in twenty-four

Digitized by Google

hours by clock-work, and as it turns round the marks of the pencil indicate the degree of pressure at each hour of the day and night.

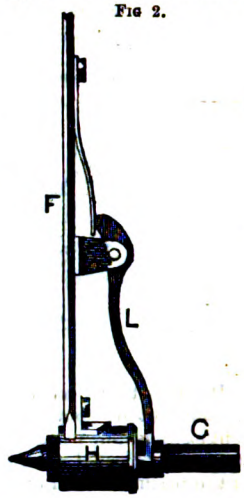
The accompanying woodcuts, Figs. 1 and 2, will illustrate the action of the apparatus. The pencil-bar F is attached to the piston-rod, and it raises or depresses the pencil G, in accordance with the pressure of the steam. The quadrant heads E E serve to guide the pencil-bar and keep it in a vertical position. The disc K is divided into radial lines indicating hours, and into concentric circles corresponding with pounds of pressure on the square inch. The pendulum bob of the clock is shown at N.

Fig. 1.



The metallic spring pistons and plungers exhibited by Messrs. Parkin and Co. of Sheffield, No. 22, if they possess the advantages attributed to them by the patentees, will prove a valuable invention. It consists of an elastic pressure ring, which is made elastic by indents or slots in opposite directions and of more than opposite depth, which make the ring spring in circumference when a wedge is forced into the ordinary opening for it, and thus enlarges the ring to the requisite degree. This elastic ring is so formed as to yield up and down, and by this means it enables the piston to work with greater facility. It is stated that these pistons will resist a pressure of 500 lbs. to the square inch.

Fig 2.



The annexed woodcuts, Figs. 3 and 4, exhibit the completed piston and the structure of the elastic ring. The indents are shown at B B; the wedge is seen at C, and the opening into which it is forced is marked at D.

Among the domestic wants of the present day which mechanical science has failed to supply is a cheap and effectual water meter, which shall enable those who are supplied with water to measure the quantity they use as easily as the consumers of gas now tell the number of cubic feet of gas that they burn by the gas meter. Water companies and individuals would be equally benefited if water could be sold by measure; for those who employ it carefully are, at present, compelled to pay for the reckless waste that frequently takes place, to compensate the companies for the loss. No water meter has yet been constructed that is generally applicable, and the only one exhibited (No. 33) is adapted to high pressures, and is much too costly and complicated for general use. It is constructed like many others on the principle of the double-action steam cylinder, each stroke of the piston being marked by an index, and measuring the quantity of water contained in the cylinder. There has been some objection raised on sanitary grounds to the measurement of water, which it is said should be used without stint; but the cost of the quantity really needful would be so insignificant as not to prevent its sufficient use, and the paying only for what is used, and not for the extravagant waste of others, would no more stint the requisite quantity than the measurement of gas diminishes the requisite amount of light, though it restricts the wasteful and injurious consumption of gas. The difficulty of measuring an aeriform fluid is much greater than

Fig. 3.

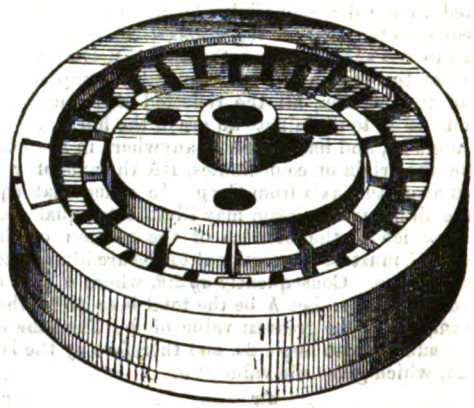
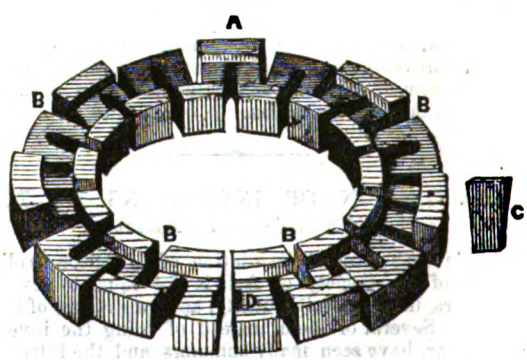


Fig. 4.



Digitized by Google

that of measuring a liquid, and if one half the amount of ingenuity that has been bestowed on the perfection of gas meters were exercised in the production of a generally applicable measurer of fluid, instead of a single machine that is only suited for special occasions, we should have numbers of water meters exhibited.

The models of railway chairs, of sleepers, buffers, and brakes that are exhibited we shall at present pass unnoticed, as the vast varieties of contrivances for improving the permanent way, and for stopping trains when in motion, render it impossible, without a very careful examination and comparison, to ascertain whether those now exhibited differ in any material respect from those that have preceded them. There is however one large model (No. 60) representing several contrivances for the prevention of accidents on railways that deserves notice, from the completeness of the arrangements for making signals and for rousing the attention of the engine-driver to danger. Messrs. Whitworth and Gibson's inventions are rather improvements on those previously known and partially adopted than original contrivances. On approaching a semaphore with the danger signal displayed a raised projection near the rail strikes a trigger on the engine that sounds the steam whistle, so that whether the signal be seen or not, warning is given to the driver. The engine itself works the semaphore in passing, and elevates the danger signal; and as it nears a station pulls a wire that sounds a bell to give notice of the coming train; one of the chief points claimed by the patentees being an improved compensator which operates as a self-acting regulator, and keeps the connecting wire always at the same tension, so as to insure its ringing the bell. In all the other arrangements the patentees claim improvements by which the making of the signals we have mentioned are facilitated and rendered more certain in their action.

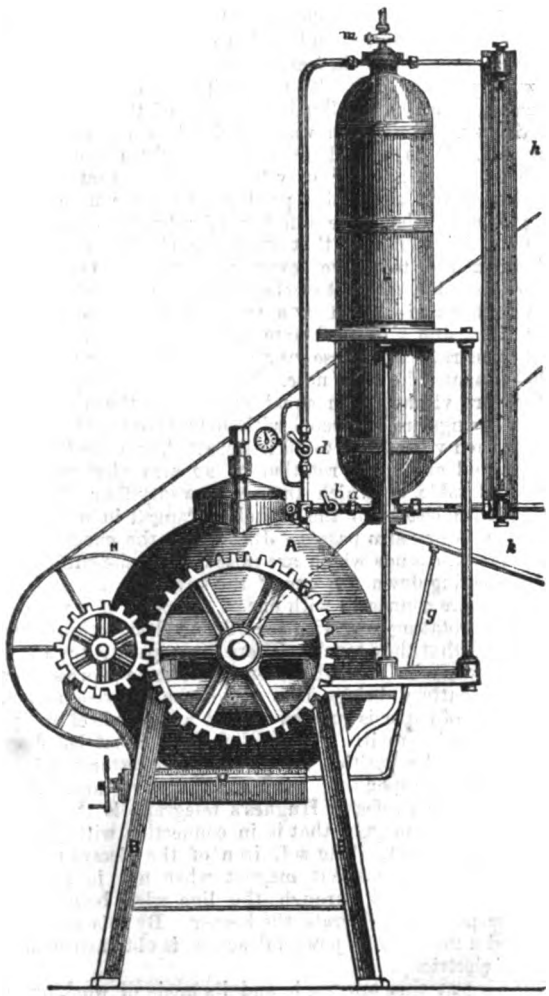
The Manchester Cotton Supply Association have directed the attention of the machinists of this country to the production of an improved machine for the dressing of cotton, and have sent for exhibition an Indian churka or cotton gin (No. 74), for the purpose of showing the implement at present used. The committee of the association intend, at the suggestion of the Bombay Chamber of Commerce, to have a trial of the merits of the gins that may be constructed in response to this invitation, and offer premiums for the best. There are eight objects to be accomplished by a perfect cotton gin, which will task the utmost efforts of inventors to combine in a machine of low cost, such as the natives may purchase; one of which conditions is, "That the machine be able to do its work faithfully in spite of carelessness or neglect." Notwithstanding this invitation and encouragement only two cotton gins are exhibited, neither of which seems to comply with the required conditions, and one of them (No. 75, exhibited by Messrs. Garnett, of Cleckheaton), is intended for operations on a large scale, though it may be worked by two persons, and produce by their labour, as stated, 200 lb. of cleared cotton per day.

A hand-planing machine (No. 83), intended for the use of philosophical instrument makers, is exhibited by Messrs. Muir and Co., of Manchester. It is worked by a continuous rotary motion of a small fly-wheel turned by hand. The tool is moved by elliptical gearing, which produces a nearly uniform forward motion, with triple speed in turning. The compactness of this arrangement will make it a convenient accessory to the workshop.

A brick, tile, and pipe moulding machine (No. 86), invented by Mr. W. A. Smith of Belper, deserves attention. It is intended for stiff plastic clay, which is pressed by two cylinders through a perpendicular channel into two sets of moulds open at top and bottom, and fixed on a frame that moves to and fro, so as to bring the moulds alternately under the feeding channel, and under pistons which force the bricks out of the moulds. This machine, it is stated, will produce 25,000 bricks in ten hours.

Machinery has for some time been advantageously employed for making bread, and the cleanliness of the operation, compared with the method of kneading the dough with the hands or feet, is calculated to bring it into general use. There are four models of such machines exhibited, the first of which shows the new mode of making bread by mechanically aerating the flour and water. Unfermented bread has, indeed, been made for some years past, but the plan adopted is to employ carbonate of soda and muriatic acid, by which the carbonic acid is liberated from the soda and aerates the dough, whilst the combination of the acid with the soda forms salt, and thus becomes innocuous. There are however several practical objections to this chemically-prepared bread, which have prevented it from coming into general use. It is to be hoped that none such will prevent the aerated from supplanting the fermented bread. The process as adopted is this:—A strong globular iron vessel A, capable of bearing considerable pressure, serves for the kneading-trough. Connected with it by pipes is an elongated copper cylinder, tinned, L, which must also be capable of bearing strong pressure. Into this vessel, which is nearly filled with water, carbonic acid gas is pumped in the same manner as in making soda-water, but there is no agitator to mix the gas and water together, for the gas that does not combine with the water in passing through it is conducted by a pipe into the kneading-trough, into which the requisite quantity of flour and salt have been introduced. When a sufficient quantity of gas has been forced into the water the latter is admitted into the flour, and they are mixed together into dough by the revolution of an iron axis, on to which strong mixing arms are fixed. A water-gauge serves

Fig. 5.



to indicate when the proper quantity of water has been admitted to the flour, and the dough is stated to be perfectly mixed in about five minutes. The dough is then *drawn off* into moulds or baking tins, when the carbonic acid compressed within it expands and produces the lightness of well-fermented dough. It is stated in the description of the apparatus that the vessel must be strong enough to bear a pressure of 300 lb. on the square inch; but this must be a mistake; it is most probably a misprint for 30 lb. We have tasted very good soda-water that had a pressure in the machine of only 15 lb. on the square inch, and three or four atmospheres of pressure are the utmost that the strongest bottled soda-water contains. If one-half the pressure mentioned in the printed description were needed it would be an effectual bar to the practical application of the plan.

In two of the other bread-making machines, No. 100 and 101, the same plans are adopted as in the Government biscuit-making factories, with this exception, that yeast and salt and more water are added to the flour. Mixing arms fixed on to an axis work the

Digitized by Google

flour and water and yeast into a consistent dough, which is then passed through rollers several times and cut into sizes fitted for loaves. The object of the fourth machine, No. 100, exhibited by E. Stevens, is merely to assist the usual operations of making bread.

One of the greatest attractions of the exhibition is the printing telegraph of Professor Hughes, the performances of which have for some time past excited much attention. Printing telegraphs which transmit messages printed in Roman type, are no novelty in telegraphy, for even before the needle telegraph was in practical use we remember to have seen experimental printed messages transmitted from a distance of seven miles. Mr. House's and Mr. Brett's telegraphs have more recently brought this form of transmitting telegraphic messages to a great state of perfection. They were, however, slow in their operation, and could not correctly print above forty letters a minute; but Professor Hughes with his instrument is represented to be able to transmit upwards of seven hundred. This telegraph does, indeed, seem to work with marvellous rapidity, and we have seen a sentence of forty-four words printed by it in less time than it would take to write them with pen and ink. The principal novelty of the apparatus consists in the application of one of the laws of sound to obtain synchronous movements in two or more distant instruments. It is well known that a given sound is produced by a given number of vibrations, and that when two steel wires of the same size produce the same note they are making exactly the same number of vibrations in a second. It is upon this principle that Professor Hughes regulates the two instruments to move exactly together. On each instrument there is a thin flat steel spring of the same size, to which rapid vibrations are given by a train of wheels impelled by a heavy weight; and a musical note is produced. A small sliding piece of brass regulates these vibrations, so that the two may be adjusted to sound the same note. When that is done, it is known that they are vibrating an equal number of times per second. The steel springs are connected with detents on toothed wheels, so that at each vibration a tooth is liberated, and the wheel turns rapidly round and gives rotation to an arm that passes over an insulated table, on which there are twenty-four slots, corresponding with letters of the alphabet, ranged in a circle, over which the rotatory arm passes. Just below the surface of these slots are metallic studs which are raised above the surface of the table by pressing down any one of the keys of a key-board; and as the studs are connected with one of the poles of a voltaic battery and the rotating arm with the other, voltaic action is excited every instant that they touch. There is a separate key for every letter of the alphabet, and whenever one of them is pressed down, the voltaic battery brings into action an electro-magnet, by which a strip of paper is pressed against a type-wheel and prints the letter opposite to it. The type-wheel, it must be observed, is brought into the position for printing the letter required by touching the corresponding letter on the key-board. Another leading feature in Professor Hughes's telegraph is the construction of the electro-magnet that is in connection with the corresponding instrument. The soft iron of the electro-magnet is magnetised by a permanent magnet when not in action, the electricity transmitted through the line wire being used to reverse the poles and liberate the keeper. By this arrangement it is stated a much more powerful action is obtained by a feeble current of electricity.

On looking at this telegraph and its mode of working, there seem so many elements of uncertainty in its action that we should be at once inclined to say it was impossible the two instruments would work correctly when separated; but we understand that it has been proved to work satisfactorily between London and Liverpool, and transmitted the Queen's speech in a marvellously short time. As exhibited at the Society of Arts, with only one instrument in action, it is no test of its ability to transmit messages from one to the other.

Building and Sanitary Appliances.

Under this head several things are exhibited worthy of notice, among which are the dry and the wet gas meters of Mr. N. Defries (236, 237), and Geyelin's gas burner regulator. Hart and Son, of Wych-street, exhibit (243) a mediæval gas standard, the artistic character of which is what might be expected from their well-known reputation. No. 244, a patent chandelier, by John B. Smith, is an arrangement intended to supersede the ordinary method of raising and lowering by means of the hydraulic tube and balance weights; instead of which is used a quick-travelling internal screw, by which the chandelier can be raised or lowered as required. The advantages claimed for this invention are that it prevents accidents arising from the breaking of the chains to which the weights are attached; and dispenses with the necessity for using water to prevent the escape of gas, as, when once fixed, it requires no further attention.

Among the gas stoves exhibited there are several worthy of consideration. The first we notice is No. 437, a sanitary gas stove and standard for gas light; R. W. Giblett, architect, and F. W. Campin, 156, Strand. This is an arrangement intended to secure the removal of smoke or foul air without the aid of the unsightly pipes which for this purpose are usually carried through the side of the apartment. Two tasteful designs for such a gas-warming apparatus are exhibited, one mediæval, the other of modern character, both proving that such an apparatus need not be offensive to the eye, as is generally the case. A hollow pillar or standard open at top and bottom is substituted for the ordinary smoke and foul air funnel, and at the top of this hollow pillar is a gas light, which is not only useful for illumination, but ensures also, by its heat in the upper part of the interior of the pillar (as well as by the effect of the pillar considered as an upcast air shaft), the ascent of the smoke and products of combustion to the top of the room, which can be ventilated at top by an Arnott's valve or otherwise. The hollow pillar and gas light must be carried up sufficiently high to be above the heads of persons in the room. We think this stove is an effort in the right direction.

Another invention, "A Stove with apparatus for purifying the air" (247), consists in a stove with or without a flue, inclosed in a case with which it is not in contact, the air of the room being admitted by apertures in the lower part of this case, as likewise the external air by a pipe connecting it therewith. From the top of this case the heated air passes to a hollow shelf or projecting case, the edges or sides of which are perforated. The top surface of this shelf or case having a fountain pipe issuing therefrom whereby a small fountain is kept playing beneath a glass shade, the streams from which are continually dropping into the shelf or case, and thus the heated air which has to pass through this shelf or case is purified before it issues from its perforated sides into the room. This invention will of course be unavailable where a water pipe with sufficient pressure cannot be obtained.

A third invention, though not particularly novel, appears to be the right thing to combine with that first alluded to, whenever it can be readily done; this is "The ventilating gas lamp for drawing-rooms," T. C. Hine, Regent-street, Nottingham (No. 438), in which the products of combustion are to be collected in a glass dome, the top having a tube carrying these products into the smoke flue of the apartment. There being also an arrangement by which fresh air heated or not can be admitted, so as to raise or lower the temperature as required.

Mr. White exhibits a modification of the same idea in his gas stove for the purification of the air in large buildings, which, he states, has been applied in Holy Trinity Church, Finchley.

No. 252, Mr. John Roberts of Upnor, near Rochester, exhibits a stove in which a smokeless fuel is to be burnt, which fuel, however, he does not exhibit or describe except by stating that its cost is 1*s.* 6*d.* per bushel, and the residue of the combustion is valued at 6*d.* per bushel. What this fuel is that burns without any resulting deliterious product we have to conjecture. There are some plans for smokeless fire-places for coal-burning which appear to be very ingenious, though probably too complex for ordinary domestic service.

No. 275, Specimens of veneers adapted for fixing in plaster walls (the London Parquetry, Victory Works, Camberwell). These specimens are veneered on cement, may be applied at much less cost than the ordinary panelling, and are said to offer no inflammable body in case of fire.

No. 276 is a specimen of wood carving by machinery (Cox and Sons, Belvedere-road, Lambeth), consisting of a bench-end with poppy-head, showing three styles of carving to which the machine is applicable, viz,—cutting the tracery, which can be done from an outline pattern; working the crooked moulding round the outside edge of the bench, and carving the natural foliage in the poppy-head. The specimen shows the amount of work that can be done by the machine, no hand-labour having been employed. This is undoubtedly a very efficient system of mechanical carving.

Digitized by Google

MARINE ENGINES.*

The Purchase and Cost of Steam Machinery.

In the directions given to the committee by the Lords Commissioners of the Admiralty particular attention was directed to this subject, and the committee, as well from their anxiety to do justice to the directions they have received, as from their strong conviction of the great importance to the country that the large sums devoted to the purchase of steam machinery should be properly laid out, have given special attention to the manner in which purchases should be entered into, and also into the cost, marking at the same time where there has been in these transactions any want of economy that ought in future to be avoided.

As a preliminary remark the committee would beg leave to observe that the improvements lately made in steam engines and boilers have a tendency to increase their cost. The tubular boiler with brass tubes costs more than the flue boiler, and the direct-action engines for propelling the screw are not only more expensive to purchase than those used for the paddle-wheel, but require a greater expenditure of tallow and oil for facilitating the motion. It would be easy to state many more changes connected with the structure of engines which have at all events required for the present extra expense.

In drawing attention to examples where the committee believe that money has been extravagantly laid out, they refer only to cases where either the vessel or engines were indifferent, omitting the cases of superior engines; for it is always some satisfaction when a good article is obtained, although the price may be large.

The hull of the Sans Pareil, of 70 guns, without masts, cost £89,032. The present engines and boilers of 400 horse power have cost the government £50,126; the reason of this large expenditure was owing to the first engines and copper boilers having been found useless: they were returned to the makers (Messrs. James Watt and Co.) with £7500 for another pair of engines and iron boilers. It is quite evident that the mistake here was purchasing the first engines with their copper boilers. With the experience that even then had been obtained of copper boilers their purchase was at all events inconsiderate. The Janus, a small steam vessel, was built in 1846, at a very considerable expense; her hull alone costing until sold £34,355, and her engines and boilers of 200 H.P., £29,392. In 1854 the sum of £5060 was laid out upon her machinery at Woolwich, where she remained till April 1856, when this vessel with her engines, boilers, &c. was sold for £3300. The machinery of the Sidon, of 560 H.P., cost £41,148 from Nov. 1846 to Nov. 1849.

The machinery of the Retribution from Sept. 1845 to July 1850 cost £67,246. In order to obtain great speed from the Retribution, double cylinder engines were placed on board, at a cost of £41,170, made by Maudslay and Field, of 800 nominal H.P. The authorities in 1850 determined to remove the engines, but before they were taken out they were put in order, at an expense of £2055. In 1856 an order was sent down that the engines in question should not be sold but broken up. The above was carried out, and the committee was informed that the value of the wrought-iron saved was about £2000, and when the labour employed is deducted, it may be considered that the government received about £1500.

Surveyor's Reply.

With regard to the fitting of these engines with copper boilers, it may be remarked, that in 1845 a strong feeling prevailed in favour of copper boilers, inasmuch as their use obviated the necessity of occasionally removing portions of the decks for repairs or renewal of boilers. It was therefore decided to give them a trial in the Sans Pareil.

The only instance adduced by the committee to prove the inexpediency of using copper boilers was the Volcano; but on the whole, the experience which had been obtained of the working of copper boilers in the royal navy, as well as that in respect of economy, was certainly not calculated at that time to discourage the further use of copper. The high price of copper, however, and the gradual increase in the pressure of steam, render it altogether unadvisable to use copper boilers in the present day. The total cost of the engines and boilers for this ship is somewhat incorrectly stated.

The Janus and Sidon were designed respectively by Lord Dundonald and Sir Charles Napier, and, as far as is known, ordered to be built without any reference to the surveyor's department. Lord Dundonald's ship and engine are admitted by all to have been failures. The Sidon was not a failure, she having been built nearly on the lines of the Odin, but with greater depth, for the purpose of obtaining more coal-stowage and an entire main deck—an important improvement subsequently carried out in vessels of the same class.

With respect to the Retribution, there can be no doubt that her displacement was not sufficient to enable her to carry her engines well. The only way to use them was to convert them into screw engines. This, however, their construction did not admit of, and the remaining means of disposing of them were either to sell them, or to convert their parts to such uses as they were fit for.

Every effort was used to effect the former object without success, and the Board in 1855, after full inquiry, on one of their visitations at Woolwich ordered the latter course to be adopted. The boilers had been previously converted into one large and two shallow barges. It may however be remarked, that engines alone, without boilers, coal-boxes, copper pipes, &c., are not so valuable as may be supposed; even when new their value does not exceed one-half of the original cost of the machinery complete as fixed on board. The many alterations also which they would have required to adapt them to a new paddle vessel were probably sufficient to deter any company from wishing to effect a purchase.

With the exception of those made by Messrs. Rennie and Messrs. Watt & Co. for block frigates, and subsequently fixed in sea-going ships, the engines of Messrs. Fairbairn are the only instance of screw-engines ordered by the Admiralty being broken up. The Termagant's, by Messrs. Seaward, were converted into two other pairs, and the James Watt's considerably modified. The Transit's and Urgent's, by Messrs. Napier, were made for the Russian government, and seized at the commencement of the war.

Many competent judges thought the screw system of propulsion could never be successfully carried out, and the invention had to struggle against adverse opinion, and no small opposition.

The original destinations of most of the engines to which the committee draw special attention were altered: they were put, not into "block-ships," mere floating batteries, but into sea-going ships, subject to more severe service than that for which they were intended.

There is not one screw-engine out of upwards of 300 pairs, with an aggregate horse power of above 66,000, ordered by the Admiralty since what may be called the transition year, 1845, when 23 were contracted for, which is not at this moment likely to do good service for many years to come.

It appears that some years ago, when engines were wanted for the navy it was the practice to apply to almost all the known respectable firms, giving very often a preference to those makers who could place the greatest amount of power in the smallest space. No doubt that was, at least apparently, the most economical manner of proceeding, but it introduced many bad engines into the service; for instance, the engines by Fairbairn, put on board the Odin and the Dragon, the Vulcan's engines, and those of the Sans Pareil and the James Watt. At present the contracts are almost limited to Penn, Maudslay and Field, and Miller and Ravenhill. A good deal of trouble is thus saved, and the committee have reason to believe that the best steam machinery that this country can produce has been lately received. Further, from every inquiry that the committee have made, after visiting most of the principal manufactories of steam engines, as well as receiving important information from most of the great steam companies, they have no reason to believe that the government have generally paid a higher price for their engines and boilers than private individuals have done. The committee are of opinion that although this plan of purchasing engines has been adopted by several large steam companies, still they think that the government could advantageously throw their contracts more open.

In the course of their inquiries the committee have been led to the opinion that some improvements might be made in the mode of taking the contracts for providing steam engines for the navy. The specifications do not appear to be sufficiently comprehensive; one deficiency has been referred to by Mr. Murray, chief engineer of Portsmouth dockyard, who stated as follows: "I have always been of opinion that the indicated horse-power up to which the engines are to work with a given supply of coal of average quality should be inserted in the contracts."

Surveyor's Reply.

The general system adopted by the Admiralty for obtaining engines is to specify beforehand the minimum area of fire-grate and of absorbing surface of the boiler, on which the power mainly depends, and to approve of the size of cylinder, length of stroke, and other particulars of the engine, before the tender is accepted. That eminent marine engineers would do their very utmost, regardless of cost, to realise the best results which can be obtained, is notorious.

Such being the case, it may be asked, is it probable that if the proposed condition were inserted in future contracts, that with a certain quantity of coal of "average" quality—a vague definition—a certain amount of

* Extracts from a Report to the Admiralty by the Committee on Marine Engines, with Replies by the Surveyor of the Navy.

Digitized by Google

power must be realised, it would have the effect of eliciting greater skill or judgment on the part of the manufacturers?

But further, if this amount of power were fixed at a point difficult to attain—and without so fixing it the condition would be simply useless—might it not be an inducement to them, rather than risk a failure, to endeavour to effect the object without due regard to permanent excellence or the satisfactory working of engines and boilers under the ordinary requirements of the service?

It is well known that the actual power developed by an engine, which is seldom two days alike, depends upon many circumstances other than its own merits and those of the coal and boiler; such as the draught of water of the ship, state of the weather, direction of wind as affecting the ventilation of the stoke-hole and the draught of the boiler, skill and energy of stokers, duration of trial, quantity of water blown out of the boilers to prevent incrustation, degree of expansion used, &c.; and when it is borne in mind that with a boiler of given size and construction, every experienced person can predicate within very narrow limits what power it will realise if the steam be made proper use of, the difference between the power specified in the contract and that realised would never be very great; hence the aggregate influence of the circumstances before referred to would become the chief point in dispute, and it is more than probable differences of opinion on this and on the mode of conducting the trials would lead to a want of harmony and co-operation between contractors and government officers, than which nothing more detrimental to those public interests with which they are connected could possibly happen; while on the other hand, no benefit whatever could possibly be gained.

The committee having ascertained that, on an average, if 60 represents the cost of hot-blast iron, 120 represents the cost of cold-blast iron, which also may be taken as their relative mechanical value, would strongly urge upon their lordships the necessity (seeing the temptation is so great) of taking the most stringent steps to prevent the introduction of any portion of hot-blast iron into the castings required for the government engines. The committee would further add that they believe a large proportion of the breakdowns that take place on board steam vessels proceed from the use of this very inferior metal.

Surveyor's Reply.

With regard to the use of hot-blast iron, it is but just to those manufacturers who have been employed by the Admiralty to say that there is no reason whatever to suppose, nor indeed is such an imputation made against them, that they have used it injudiciously.

The principle of prohibiting the use of a material which when used with judgment is unquestionably productive of benefit, because it is cheap and may be improperly used by unscrupulous persons, cannot be defended.

The adoption of such a principle would be calculated to discourage improvements and check advancement in the manufacturing and mechanical arts; indeed in the present day it would be as anomalous as it certainly would be contrary to sound policy.

At present no engines are made at the government factories; repairs alone are done there, and those sometimes of a very extensive kind. When new engines are purchased at manufacturers', the boilers are furnished with them: the boilers when worn out are replaced by those made at the government factories. Considering the ample accommodation afforded at the government factories for the construction of boilers, there are strong reasons that the purchase of them ought to be at once discontinued, and all the new contracts for machinery should be confined to engines.

Surveyor's Reply.

If this recommendation were ordered to be carried out, no doubt many of the difficulties and objections which at once present themselves, and which appear of a serious character, would not be found insuperable; but it is quite obvious that a proposition to increase to such an extent the system of costly manufactures in the dockyards could not be decided in the affirmative without grave consideration, and a more close investigation and a fuller inquiry than it appears to have undergone by the committee.

But looking to the almost inevitable growth of a system so congenial to the feeling of the officers of the factories, even if its expansion were rigorously discountenanced by authority, and to the consequent increase of the permanent charge of those establishments, it seems at least doubtful whether the reasons assigned are sufficiently weighty to justify a departure from the system hitherto maintained.

The committee also believe that many of these advantages would be gained by government making a proportion of their own engines. The only serious objection that has been made to this representation is the one which is thus stated in Mr. Murray's evidence: "My reasons against making engines at the factories are, that I believe we should lose the benefit of the improvements that are taking place in the mercantile world; and also those improvements that we are entitled to expect from the employment of the best engineers of the country in making new engines and boilers for us on their own designs." The committee however believe that if proper precautions are taken the danger here referred to might be obviated. The committee have every reason to hope that many of the engines constructed at the government factories will be as serviceable as many of the government constructed boilers, which both in respect to excellence of workmanship and material are superior to any boilers that have as yet been made in this country. In their opinion the factories of Keyham and Portsmouth would of themselves supply abundant dimensions for doing a great deal more work than what is proposed.

Surveyor's Reply.

They also suggest that the remaining engines should not be obtained as heretofore from the engineers whose plans the committee have decided to be the most best and the most suitable for ships of war, but that two or more of these plans should be selected, or others invented by government officers, that complete working drawings and specifications should then be prepared and placed in the hands of such manufacturers as may be willing to undertake work under these conditions. Engines may, it is assumed, be thus obtained at a reduced price, and of the same or superior excellence.

To expect, however, to obtain in this manner engines of the same excellence as those manufactured by the inventors themselves, at all events for some time to come, is altogether unreasonable. For every kind of engine there are particular adjustments and allowances required, and for certain parts a suitable selection and treatment of materials, a knowledge of which can be acquired only by long practice, and cannot be communicated by any drawings or instructions. It relates more especially to those practical details learned by experience in constructing a succession of engines on the same plan. Moreover, it would be difficult if not impossible to ensure the same excellence of workmanship in ordinary engineering establishments.

These considerations, however, are at present beside the main and the preliminary question, namely, whether or not such a mode of proceeding, whatever its presumed advantages may be, is one which any government would feel themselves justified in adopting.

High-pressure Steam.

The important question regarding the expedience of using steam without condensation, or, as it is commonly called, high-pressure steam, has occupied much of the attention of the committee. For many years high-pressure steam was considered altogether unsuited for marine purposes, more particularly in men-of-war, but during the Russian campaign, when there was so much demand for gun-boats, recourse was necessarily had to the high-pressure steam engine, because there was not sufficient time to construct the more complicated condensing engine.

The great and paramount evil of the high-pressure engine for marine purposes, and which the committee think ought to decide the question, is the necessity of using salt water in the boilers. The salt soon accumulates about the tubes, in spite of every care that can be taken, and full power can only be used for a very short time. The boilers themselves deteriorate before their due time, and the efficiency of the vessel as a man-of-war, that ought to be ready to act at a moment's notice, is lowered. Upon this head all the witnesses examined agree that they see no means of remedying the inconveniences that accrue from being obliged to use salt water in the high-pressure boiler. Under these difficulties, as rendering the continuance of high-pressure engines most inexpedient, the committee naturally turned their attention to ascertain if the engines of high-pressure gun-boats could not be altered. The committee recommend that when any of the high-pressure engines placed on board the gun-boats or steam batteries require repairing, that a condenser and two air-pumps should be fitted. They do not, however, propose to disturb the present arrangement of exhausting up the funnel, in the event of its becoming necessary at any time to return to the use of high-pressure steam.

Surveyor's Reply.

For general marine purposes few have advocated, and few at present would advocate high-pressure steam. For special purposes, however, it may have its value. The difficulties attending its use, as was expected, are entirely confined to the boilers; but these difficulties, although aggravated by having to use salt water, will it may be hoped be gradually surmounted, or at least in part. Be this as it may, the recommendation of the committee to convert all the engines of the gun-boats into condensing engines does not appear to be based upon sufficient experience.

Digitized by Google

Boilers.

On board a steam man-of-war there are peculiar circumstances that must be attended to in the construction of boilers; for instance, the space for them is not only limited, but they are still further limited by being necessarily below the water line. Now the great desideratum has been not only to adapt the boiler to this limited space, but further, to spare weight as much as possible; and with this to put in a boiler that would have the power not only of generating steam economically, but with sufficient rapidity to supply the engines. For this purpose what is commonly called the tubular boiler has been adopted, and no doubt the reason it answers so well is this, that the greatest possible amount of heating and grate surface is obtained.

The committee are decidedly of opinion that the common tubular boiler is, of all known boilers, the best adapted for men-of-war, whether applied to high-pressure or condensing engines. The only other species of boiler that has come under their cognizance, and that has been actually tested at sea, at all likely to answer on board Her Majesty's ships, is Lamb and Summers' patent boiler; they are largely used in the mercantile marine, and are no doubt well planned; but after mature examination, the committee do not recommend them to the Admiralty for trial. At the same time, it is but justice to state that they do not see any positive objections, nor could it be thought a wasteful expense to give them a trial.

When first the tubular boiler was introduced into the navy the tubes were made of iron; that metal has now been abandoned in all cases, and brass tubes are substituted, except where high-pressure engines have been placed in steam-vessels, and in these cases iron tubes are now used. There can be no doubt that brass tubes are much better adapted for naval purposes than iron ones. One objection to iron tubes is, that they deteriorate so rapidly when the vessel is laid up in harbour as to become unserviceable after long inaction.

Engines.

All the marine engines, whatever may be the particular plan of construction adopted, which have been lately made in this country by the manufacturers of established reputation, when they come to be examined with mathematical accuracy, and when their motion has been analysed, have been found to give out so nearly the same amount of power, that the difference amongst them is hardly worthy of consideration.

It is more than probable that no form of marine engine, in a mere engineering or working point of view, either for driving paddles or the screw, is superior to the upright inverted cylinder engine; but this formation, from its exposure, is evidently unfit for vessels intended for the purposes of war. The principal requisites for steam machinery for a man-of-war, different or partly different from the machinery which is to be placed on board mercantile vessels, are as follows:—1. All the machinery must be well beneath the water-line. 2. The engines must be simple in construction, at least as simple as is consistent with efficiency. 3. All the parts of the engine must be readily and easily accessible, so as to be easily removed and replaced when they require repairs.

The committee have no hesitation in giving their opinion that with our present knowledge, if the government ever again require engines for propelling the paddle-wheel, that the "oscillating" and "double cylinder" engines are the two best, the latter especially (patented by Maudslay and Field) where great power is required.

The committee have no difficulty in coming to this conclusion: that of all the variety of engines that have been purchased by government for our screw ships of war the following are so far superior to all others, that no engines of an older make should ever again be put on board. The engines to which they now refer are—1st. The single piston-rod engine, with the connecting rod attached direct to the crank shaft, and with a single flat guide. 2nd. The engine commonly known as the Trunk Engine, and patented by Messrs. Penn and Sons. 3d. The double piston-rod engine.

The committee are of opinion, that with our present knowledge of steam machinery, that up to 300 collective nominal horse power there is no engine for men-of-war superior to the single piston-rod engine with a single flat guide, and they are not prepared to say that above that power its qualities may not be found equally good. And that the trunk engine, as constructed by Penn and Sons, has answered so extremely well, more particularly where great power is required, that the committee recommend that with such improvements in the details of these two engines as experience points out, they should be considered for the present the naval engine.

The committee have also made investigations into the relative advantages of the arrangements adopted by the different firms who have constructed the double piston-rod engine; and they are of opinion that in the general construction Messrs. Maudslay and Field's engines are more simple than those of other engineers who may have adopted this species of engine; and they think also that the particular parts of their engines are more accessible and more easily removed.

Surveyor's Reply.

The captain of the steam ordinary at Devonport, in his letter to the committee of the 9th September, expresses an opinion that boilers without being urged should be capable of supplying their engines with as much steam as they can condense, even when working at their utmost power, and consequently he considers it a bad arrangement when, in order to obtain the utmost power of the engines, the fires have to be urged.

The inspector of machinery afloat of the steam ordinary at Devonport is of an opposite opinion, as regards the quantity of steam the engines might be able to consume. He says, and very reasonably, "I should advocate carrying the steam further into the cylinder, say 8-10ths of the stroke, as by so doing, in an emergency such as getting a ship off a lee shore, or towing, the power could be increased."

Now this could be done, indeed it has been done sometimes, but not without a difficulty, and not with quite so good an adjustment of the slide valve. Moreover, the quantity of power would not be greatly increased, and not in any degree in proportion to the extra quantity of steam used.

In some cases, doubtless, such an arrangement would be attended with benefit; but on the whole, the ordinary one is generally admitted to be practically the best. That it cannot be far wrong may be inferred from the fact, that this officer is desirous to alter it in one direction, and the captain of the steam ordinary in the opposite.

If the former alteration were adopted, the boilers would be pronounced bad, because when the engines worked at the full velocity the additional supply of steam could not be obtained, and it would have to be used expansively to the same extent, exactly as it now is under the same circumstances. Still, more might be used, if it could be had; therefore it would be said the boilers are short of steam. With the latter alteration the boilers would be pronounced good, because the discretion which is now vested in the commander of a ship to fill the cylinders of the engines, say to two-thirds of their length at the utmost, would be limited to something less, which lesser limit he can, under existing arrangements, confine himself to whenever he thinks fit. The possibility of an officer exercising unsound judgment in such a simple matter, and urging boilers when they ought not to be urged, cannot be a sufficient ground for virtually reducing, at least under some circumstances, the power which engines are now capable of giving out.

Working Steam Expansive'y.

It has long been a complaint, and a just one, that owing to the quick motion of the direct-acting screw engines, the expansive gearing on board our men-of-war seldom acts for any length of time. It is found either that they have to be removed on account of breaking, or from the apprehension of their breaking, when the link motion now generally adopted in the navy is left as the only means of expanding the steam. In order if possible to obviate the above complaint, the committee at an early period of their labours directed their attention to the improvements that could be made in the direct-acting screw engines, so as to enable steam to be used expansively with the greatest advantage. They soon saw that with the direct-acting screw engines to work the steam expansively by means of cams was out of the question; and after much inquiry and examination they came to the decision of recommending that to all new engines, and to those undergoing repairs, should be fitted what is called the "expansion flat gridiron valve." This valve is worked direct from the shaft, with a separate eccentric.

Surveyor's Reply.

There is doubtless the want of a good and simple expansion valve fit for quick-working engines, although it is practically of less importance now than formerly, for in the present day all such engines are fitted with what is termed a link motion, which, within certain limits, does all that can be desired, and beyond those limits goes far to meet the remaining requirements. Still a good and simple expansion valve is a desideratum, and it has occupied the attention of marine engineers for a long time.

The fact that such a valve has not yet been designed, if we except that of Messrs. Maudslay, applied by them to some of their more recent engines, and which may, perhaps, be found practically unobjectionable, sufficiently shows that the difficulties are not easily surmounted.

Digitized by Google

The one suggested by the committee, which has not the testimony of any eminent engineer in its favour, together with many others, have been fully investigated; its action, however, is admitted to be imperfect, and this is probably the reason why it has not been preferred to others.

Superheated Steam.

Steam, as generated from the boiler, whatever be its temperature, contains such a quantity of moisture as makes it act in some measure as a lubricator to the cylinder. If, however, the steam were sufficiently superheated apart from the water, so as materially to increase its elasticity, the consequence of its drying qualities upon the working parts in the cylinder would be such as to cause either leakage or much friction. From this it may be deducible that the superheating of steam out of contact with water can only be beneficially employed for the evaporisation of any priming water carried out of the boiler by the steam pipe.

From what has been here stated, the reasons may be explained why the experiments made on superheating steam have given such different results. When the boilers were indifferent, and there was much priming water to evaporate, the gain from using this process appeared large; with good boilers, on the other hand, the gain appeared small.

If it is desired to secure to the navy the advantages of the process of drying the steam, the committee would recommend an addition to the steam space to be made round the uptake of the funnel.

Surveyor's Reply.

For many years all doubt has vanished respecting the fact that considerable economy arises from the use of superheated steam,—the degree of economy depending, as might be expected, upon the extent to which the principle is carried out, and upon the mode adopted for superheating the steam.

But the late Dr. Haycraft's experiments, and others, as well as those recently made in the Black Eagle, and now being continued in the Dee, prove incontestably the fact of economy, which generally, at a moderate estimate, may be taken at about 20 per cent.

The main points yet to be satisfactorily determined are—1st. Will no mischief be done, or greatly increased wear occasioned to the working parts of the engines in contact with this kind of steam at a high temperature; and whether, without greater care and attention than can be insured, is serious damage to the machinery likely to happen occasionally? 2nd. What is the most practical mode of carrying the principle into effective operation?

The subject cannot now be lost sight of, or fail to be prosecuted with assiduity. All persons interested in steam matters are fully alive to its importance, and well acquainted with what is being done.

On the Amount of Steam Power that can with most Advantage be placed on board Men-of-War.

Many mistakes appear to have arisen in making the calculations for ascertaining the exact amount of steam power required for any particular ship. The source of these mistakes has often been sufficiently obvious, and the greatest uncertainty will always prevail as to results, where there has not been the most accurate estimate of the differences of resistance consequent upon different formations of vessels, as well as taking into account the capability of the ship when fitted with an engine for carrying weight.

The error has been sometimes committed of putting too great power on board of our steam-ships as at present planned.

The Diadem, with 800 nominal horse power, although a noble ship, is quite a case in point. In perfectly smooth water and little wind (force 3) it required an indicated horse power of 2·390, or in other words, nearly three times the nominal horse power, together with a consumption of 60 tons per day, to obtain 9·9 knots from the Diadem.

The following is an important example, to show that the length of a ship may be increased, that 300 tons more weight may be placed on board, the immersed midship section being unaltered, and yet that the speed may remain the same, with the same engines and boilers. The Peninsular and Oriental Company's ship Candia before being lengthened was 280 feet long, and her trial at the measured mile in Stoke's Bay gave 12·5 knots. This vessel was lengthened 35 feet before the midship section, and on her second trial had 300 tons more weight on board than on her first trial. Her second trial took place on the 12th August 1857, also at Stoke's Bay, and the speed of the Candia was then 12·45 knots.

Surveyor's Reply.

It appears from the tenor of the remarks of the committee on the forms of ships, that they suppose there are some persons holding office in the government service, and who, having made this subject their especial study, and being well acquainted with the dimensions, forms, and other elements of Her Majesty's ships, and of many others, as well as with a vast number of authentic facts relating to their actual performances, are not yet aware that fineness of lines is conducive to velocity, and essential to high velocity. Such an opinion, however, it may be confidently stated, is altogether erroneous.

Our frigates have now reached the length of 300 feet. Almost the first of the large ships designed especially for the screw were the Duke of Wellington, Agamemnon, and Imperieuse, when a considerable step was taken; the Agamemnon having been made 230 feet in length; the longest sailing two-decker being only 205 feet. It being found that these ships sailed and worked quite as well as the ordinary sailing ships of the same classes, it was decided to make a further step in this direction; and, in consequence, the Renown was built of the still greater length of 245 feet, to enable her to receive larger and more powerful engines than the Agamemnon, and to give her finer lines with a view to increased speed under steam. The trial of the Renown having proved so far satisfactory, it has been decided to take a yet further step by building the Bulwark, and other ships of this class, of the still greater length of 252 feet, for the purpose solely of making them of still finer forms for greater speed. High speed under steam is, in the present day, considered of such paramount importance, that no reasonable expense should be spared, nor means left unresorted to, which are likely to accomplish it, provided the sailing and other essential properties of ships are left intact.

But in still further increasing the length of ships there is another and very important consideration, whether, looking at the fineness of their extremities, and weight of their machinery, it will be possible to make ships built of wood of sufficient strength to retain their forms for any length of time. It has always been felt that it is by means of experiments at sea chiefly that any reasonable expectations can be entertained of advancing the art of designing ships and their machinery, and with this view, experimental trials of ships have been made from time to time when their services could be spared; but the absolute necessity for such experiments has been still more felt since the introduction of the screw, for this has rendered necessary an entire change in size, proportion, and form of ships, in consequenee of the enormous bulk and weight of their machinery and coals, and of their being required to sail well, to steam well, and also to behave well under sail and steam combined.

Far more complex and difficult considerations are thus introduced, and almost incompatible conditions required; in fact, so complete a change has been made in Her Majesty's navy within the last few years, that the former accumulated experience derived from the behaviour of sailing ships becomes comparatively useless as a guide for the construction of modern steam-ships.

Data, however, founded on the actual performance of these ships at sea are now fast accumulating, and it may be expected that the conclusions drawn from them and from an elaborate comparison of the lines and calculated elements of ships of different classes, will gradually but surely point out the nature of the improvements which are still needed, and the best mode of effecting them. Immediately connected with this subject is that of the engine power which ought to be used. This is also an important question, and one involving difficult considerations, which experience and observation will alone help us to deal with satisfactorily. It by no means follows, that because a vessel carries a wave before her when urged to the utmost at the measured mile, she has more power than can generally be used advantageously. This is an exceptional case, and should not of itself be taken as a criterion of the proper amount of power required for general use. A certain speed for every particular class of vessel may be regarded as essential, at which speed the power placed in her should be capable of propelling her under ordinary circumstances without difficulty.

The rule generally has been to place in ships of war as much power as the displacement and general arrangements connected with the necessary stowage of the ships admit of being placed in them, and in no instance has the amount of power so determined been reported too great by the officers who have commanded such vessels; but, on the contrary, complaints have been sometimes made of its being insufficient.

The next case of too great power, in reference to form, is that of the Diadem. At the time when the design was made for this ship a strong feeling was entertained against increasing the length of ships, both on account of the additional cost of their construction and of the difficulty which might attend the working of them under sail, together with the greater dock and basin room they would require. These considerations have prevailed up to within a short period to prevent the lengthening of ships sufficiently to enable suitable forms to be given them for attaining high speed, except with some sacrifice of power. The Diadem, it may however be observed, was designed originally for 600 H.P. engines, and 800 H.P. engines were subsequently ordered to be placed in her, because the French were then placing engines of this power in their 50-gun frigates of about the same length. In fact, the only important question is, is the Diadem a better ship with 800 H.P. than she would be with 600, or any less amount of power? It is assumed that few practical men would hesitate in answering this question in the affirmative.

It must not however be supposed, from anything that has been said upon the subject of placing great power on board un-

Digitized by Google

suitable ships, that the committee are not desirous of guarding against the opposite extreme, namely, that of placing only very small steam power in ships, merely because they have not good lines of construction. A certain degree of speed for a man-of-war has now become essential; and in converting old sailing ships into screw steam-ships, the nominal horse power that ought to be placed on board each ship must be carefully considered in reference to the size and lines of the particular case. For instance, from the size and formation of the Queen it would probably be advantageous to place 100 nominal horse power more than should be placed on board some of the other line-of-battle ships that are being converted.

Surveyor's Reply.

The question here raised is not one of opinion, but of fact, namely, the internal capacities of the several ships referred to. This was of course ascertained in the first instance, before any suggestion was made to the board respecting their conversion into screw-ships, and if the committee had communicated their intention of expressing their opinion on the subject, the necessary information would have been freely furnished to them; and they would thus have been prevented from making loose statements, so calculated at first to convey erroneous and unjust impressions, but afterwards to lessen the confidence which the statements and opinions of a committee generally command. Instead of the Queen being capable of carrying larger engines than the other three ships, she is in fact the least capable; she has actually less available displacement than any of them, and less internal space.

The Screw as a Propeller.

Various forms of screw propellers have at different times been proposed, and various experiments made as to their respective utility; but from all these it does not appear that any form that has ever been applied to our men-of-war is superior for the purposes of propulsion to that of the common two-bladed screw, supposing, of course, that the proper pitch and diameter applicable to the vessel has been arranged. It has also the advantage of being more easily hoisted up than the three-bladed screw.

The attention of the committee was directed to the consideration of the qualities of Griffith's screw, and as its pitch is capable of being altered, they recommend its use for determining the most suitable pitch where a common screw is to be fitted for any particular ship.

There is one detail of considerable importance which the committee would recommend, more particularly as in the greater number of our screw ships the plan has been adopted, and found to answer well; it is this, that the screw shaft shall not draw in, but be fitted with a T head.

The committee cannot close these brief remarks upon this subject without strongly urging that the purchase of screw propellers should be at once abandoned, and that they should be all made at the government factories. The brass screw, on Griffith's plan, intended for the Doris, cost £637 more than it could have been furnished for at one of our own factories. And taking a general average, it will be found that upon this article of steam machinery a saving may be effected by government being their own constructors, to the amount of at least 30 per cent. upon the price at present paid, besides the certainty of having the best articles that the country can produce.

Admiralty, 24 December 1858.

In returning the Report of the Committee on Steam, their Lordships' attention is called to the observations therein made agreeably to their directions.

As regards matters of great importance, and these are comparatively few, a perusal will show in what respects the committee and the surveyor agree in opinion, and in what respects they differ.

For instance, there is a perfect agreement in opinion as to the excellence of the engines obtained for Her Majesty's ships, and as to the reasonableness of the price paid for them; but not as to the propriety of setting aside approved plans in favour of some engine to be designed by Admiralty officers, or as to the policy of setting aside the approved makers of these engines, in order to employ others to manufacture the same kind: nor do they agree in the opinion as to the policy of extending the system of manufacturing machinery in the dockyards to such a degree as would have the effect of increasing the cost of maintaining the factories by at least one-half the sum which, under the existing practice, would be voted for the purchase of new engines and boilers.

There is also no difference of opinion as to the praiseworthy manner in which the principal engine-makers acquited themselves of the trust reposed in them during the exigencies of the Russian war.

The surveyor of course agrees with the committee in their conclusion, that from what they have seen in the proceedings now adopted by the steam authorities of the navy, there is no appearance, at least for the present, of what they term "grave errors" being repeated.

With respect to the fineness of ships' forms, and the engine power which ought to be used, the committee, as might be expected, express themselves vaguely, but they seem to hint an opinion in favour of increasing the fineness of forms, and of putting engines of less power into the ordinary class of ships. Now this being a complex subject, it has been dealt with elsewhere at some length. It may be sufficient here to observe, that already frigates reach the length of 300 feet, which is necessary to give them fine extremities. Ultimately, perhaps, to keep pace with our rivals, they must be made longer still.

However this may be, it is confidently believed that no report has ever been received from an officer commanding a ship that she had too much power, unless she was unable properly to carry it, and for this clear reason, that he need not use it unless he choose to do so: and when he does not use it, which is always the case except when a great object is to be effected, he burns no more coal than if the engine were incapable of exerting a greater amount of power. Here again we must in some degree be guided by the practice which obtains on the continent.

(Signed) B. W. Walker.

THE EXHIBITION OF MR. DAVID COX'S PICTURES, SKETCHES, AND WATER-COLOUR DRAWINGS.

Few art exhibitions are more interesting—none more instructive—than those devoted to the works of one great artist exclusively. Each work is a key to the excellences and intentions of each other work; and the whole series may be considered to represent the history and progressive development of one great artistic mind. Unfortunately for the lovers of art, such exhibitions are very rare. The productions of important authors find their permanent place in the collections of connoisseurs, and are therefore, in a great measure, inaccessible to the general public. Almost necessarily then any collection of the works of an artist must be of a transitory and fragmentary character.

It has long been desired to remedy this great want, and to afford to the amateur, the artist, and the public the opportunity of seeing some of the finest specimens of some of our most renowned artists in the collected arrangement of one exhibition. To effect this, a number of gentlemen have formed themselves into a committee, and have made arrangements to present for a period in every year such an exhibition as is above suggested. From a casual circumstance the first choice has fallen upon the works of that simple and grand painter of English rural scenery and country life, David Cox; and the committee, having had placed at their disposal the German Gallery in New Bond-street, for a short period, in the first place opened the exhibition there; but that room being now required by the proprietor, it has been removed to 120, Pall-mall, and occupies the suite of rooms on the first and second floors. As may be conjectured, the removal thus necessitated is not so favourable for a good view of the pictures; the lighting of the rooms being derived wholly from the windows at the extreme ends: consequently, as many of the pictures are hung above the eye-level, and are not unfrequently small in size, they are not likely to gain all the attention which they really merit. We are aware however of the utter impossibility of securing suitable premises for such a purpose now that the picture season is so fully inaugurated, and though we cannot but draw the comparison between these pictures in their new locality and in that where they were on view till a week or two ago, we are rejoiced that so praiseworthy an object has been attempted, and so successfully accomplished. It may be mentioned, that while providing for the lovers of art so great a treat, the committee are most desirous to have it distinctly understood that the exhibition is in no sense a commercial speculation. The receipts will be devoted to defraying the necessary expenses, and whatever surplus may remain will be handed over to the Artists' General Benevolent Fund.

Altogether the collection will be found a highly interesting one, although the bent of the artist's mind and talents has led him into what might be thought a very monotonous style of subjects; but here the hand of genius triumphs, and invests even repetitions with a charm. A very favourite scene with our painter was always the Vale of Clywd, and even in this imperfect series of his works it forms the specific title of three pictures, while a similar character of landscape pervades some dozen or more besides. Welsh grandeur is Mr. Cox's especial study and delight: the proofs of this are manifold, and whether it be in the portrayal of a peaceful vale like Clywd or Dolydellan, or the

Digitized by Google

over-awing wonders of Penman Mawr, he is equally at home. Several noble views of our English castles will be regarded with pleasure, such as Windsor (2 views), Beeston, Barden, Dover (a very slight but beautiful sketch), Kenilworth, Dudley, Richmond, Bolsover, and Lancaster. The view of Rhyl gives an excellent opportunity for displaying our artist's skill in representing truthfully, without exaggeration, that most difficult object, the sea. We know not which of all the number—amounting to 174—is to be regarded as his earliest production, but we recognise that "On the moors, near Bettwys y Coed," as having graced the walls of the Old Water-colour Gallery so late as last season.

This exhibition is indebted to not fewer than thirty-four gentlemen for the loan of pictures, and it is stated that other portfolios of sketches and additional drawings have also been received, which will still further enhance the attraction.

SOME ACCOUNT OF THE LIFE AND WORKS OF BALDASSARE PERUZZI.

By Samuel Angell.*

In the notice of the life of Le Tarouilly, prefixed to 'Les Edifices de Rome Moderne' (the noble work of that indefatigable architect and author), it is remarked that although he possessed a just admiration for the works of Bramante, San Gallo and Vignola, the artist he preferred was Baldassare Peruzzi; and so great was the admiration of Le Tarouilly for this "artista valente" (as he is styled by Milizia) that he compares him to Raffaelle, from the resemblance he found in their characters and in the nature of their talents. The preference evinced by such excellent authority, and by one so eminently qualified from the direction of his labours and studies to form a correct judgment, has induced me to bring to your notice the works of Peruzzi, feeling assured that there are still among you some who have not been entirely led away from their early studies of Italian architecture, and that even from the Mediæval benches (crowded, and so honourably occupied as they are upon this evening of their triumph) I might possibly enlist some sympathy, if not admiration, for so distinguished an architect of the Renaissance period as Baldassare Peruzzi. Peruzzi was born early in the year 1481 at Accajano, near Siena, and he was sometimes called "Baldassare de Siena," but Vasari states, that both Florence and Volterra (as well as Siena) put in their respective claims for the honour of his birthplace. I believe, however, that we shall not be in error in considering him a Sanese. His early days appear to have been passed in the workships of goldsmiths and jewellers, after which he commenced the study of painting, copying and imitating the works of the best masters, as well as drawing from nature; and upon the death of his father, about this period, his exertions and progress were such, that he was enabled to support himself by his art, and to aid both his mother and sister. We may remark that it is probable his early studies as a painter (more particularly those of a decorative character) produced in him afterwards that freedom and facility in his architectural designs for interior ornamentation, of which he has given us such exquisite specimens in the Massimi Palaces, and other of his works. I regret that I have not sufficient data to place before you the works of Peruzzi in chronological order. I will adopt, therefore, the arrangement in which they are classed by Vasari, who informs us that Baldassare's first work (after some few unimportant ones at Siena) was a small chapel, near the Florentine gate at Volterra, where he painted certain figures with "infinite grace," after which he proceeded to Rome with his friend and brother artist, Pietro da Volterra. Peruzzi's early days at Rome appear to have been devoted to his studies as a painter, and he obtained great praise for the excellent manner in which he executed in fresco the Chapel of the Great Altar in the church of San Onofrio. He was next engaged in painting two small chapels in the church of San Rocco a Ripa, and having now attained some eminence, he was invited to Ostia, where he executed some beautiful historical representations in chiaroscuro, in the apartments of the tower of the fortress. Many of these represented combats, in which were introduced ancient armour and equipments of war. These decorative paintings are considered among the best of Peruzzi's works in that style, though it is but fair to state that he was assisted in them by Cesare, of Milan. Upon the completion of his labours at Ostia, our artist returned to Rome. His chief architectural work at this time was the celebrated "Farnesina Palace," for Agostino Chigi, on the Lungara. Le Tarouilly gives 1510 as the date of this admirable production, a work to which Vasari applied the happy expression of "Non murato, ma veramente nato." Situated as the building is upon the spot formerly occupied by the gardens of the Emperor Geta, Baldassare composed his plan upon the most simple arrangement, evidently considering it as devoted to pleasure and entertainment, rather than for a domestic residence. Le Tarouilly's three plates convey an admirable description of the edifice, with the sole exception that one of its most attractive features (the exquisite colouring of the ornamentation) is not rendered; this omission, however, is in a great measure supplied by the beautiful coloured plate in M. Gruner's noble volume, and in the Italian prints tinted in body colour.

The Farnesina owes much of its celebrity to the beautifnl pictorial embellishments of those eminent masters, Raffaelle, Giulio Romano, Sebastiano del Piombo, Daniele da Volterra, and Annibale Caracci; and, with all his fond preference for Peruzzi, Le Tarouilly allows that many parts of the exterior architecture are open to criticism; the design however is full of grace and elegance, and the ornamentation is deserving of all praise. Great portion of the enrichments in "terretta" are by Peruzzi's own hand, and the great Titian himself is said to have been deceived by the marvellous imitations of relievos. Peruzzi was next employed, according to Vasari, in executing a façade in "terretta" between the campo de' Fiori and the Piazza Giudea. It is described as an admirable performance, particularly the perspective views which were introduced in it. This work was a commission from one of the pope's chamberlains. In the Chiesa della Pace our artist painted a chapel for Messer Fernando Ponzetti (who was afterwards made a cardinal); he also painted in "fresco," in the same church, a picture for Messer Filippo da Siena, representing the Virgin ascending the steps of the temple; this picture contained a great variety of buildings, with many beautiful ornaments of various kinds.

The Palazzo Costa in the Borgo Novo (built for Jacobus Brixianus, surgeon to Leo X.) is not far distant from St. Peter's. Some attribute the architecture of it to Raffaelle, but Le Tarouilly (the best authority upon such points) is inclined to ascribe it to Peruzzi. The design is of an unpretending character, and the ground floor (as in many instances in the Italian palaces) is occupied by shops. Much study has been given to this design, particularly to the rustication, and it is upon the whole well deserving the attention of the student. The author of 'Les Edifices de Rome Moderne' has devoted three plates to the Palazzo Linotte, in the Vicolo dell' Aquila. This palace is situated near the Cancelleria (the great work of Bramante), but little is known of its date or history, and it is attributed to Peruzzi more from its style than from any authentic source. It has been ascribed also to Bramante, and to Michael Angelo, but there are no traces of the distinctive styles of those architects, and if not the work of Peruzzi, the claims of San Gallo I believe would be considered as most worthy.

The Palazzo Ossoli, in the Via de' Balestraji, is attributed to, rather than positively known to be the work of Baldassare. The simple and masterly arrangement of the plan, and the elegance of the façade partake of the master mind and hand of Peruzzi, and I think there can be no doubt that Le Tarouilly is correct in naming him as the architect.

The Chigi Chapel in the church of Santa Maria del Popolo, has been generally attributed (both as to its architecture and pictorial embellishments) to Raffaelle; but we owe it to the study and research of Le Tarouilly, supported by the opinion of his countryman Lalande, that the architecture is from the hand of Baldassare; the style and imprint are his, and the "Corinthian Order," as published by his pupil, Serlio, resembles in a great degree the one that has here been employed. Peruzzi's intimate friendship with Agostino Chigi may be fairly adduced as an additional reason for believing that he was employed in this chapel as architect, while Raffaelle (as in the Farnesina) was commissioned with the pictorial embellishments. This chapel is certainly a "Capo d'Opera!" and although I may be venturing upon tender ground this evening, in daring to uphold the Italian architecture of the XVIth century for ecclesiastical purposes, I am bold enough to admire this fine specimen of the taste and genius of Peruzzi, enriched by the master hand of the divine Raffaelle, and to join in the enthusiastic language of Le Tarouilly, "Honour

* Paper read at the Royal Institute of British Architects.

Digitized by Google

then to Chigi, to whom we owe this *chef d'œuvre*, and who has immortalised himself by joining his name to those of the two great artists, to whom he was the Mecænas!"

About this period (1520) Peruzzi appears to have been invited to Bologna, to enter into the famous competition for the designs for the façade of the church of San Petronio; an event which appears to have excited as much interest in those days, as the struggle for the Government Offices or the Spurgeon Tabernacle in our own times. We learn that Peruzzi sent in two designs, the one Italian and the other Gothic; they are still preserved in the sacristy of the church, and Vasari is loud in his praises of a perspective view; this, I presume, applied to the Italian design, for I suspect Baldassare was more at home with the five orders than he was with the pointed arch, and buttress, and pinnacle of the Mediævalists. While at Bologna, Peruzzi designed the portal of the church of San Michele, in Bosco, and embellished the monastery of the monks di Monte Oliveto, in the environs of Bologna. The cathedral at Carpi was also designed by Peruzzi at this period. For the Count Battista Bentivogli he made a design in chiaroscuro, "The Nativity of Christ and the Adoration of the Magi." As this drawing is now in our own national collection, we ought to be enabled to judge whether its merits deserve the encomiums Vasari has bestowed upon it, but unfortunately it is placed in so dark a position on the staircase as to be quite invisible to the eye of criticism. The catalogue, however, throws some little light upon its history, for we learn from it that the drawing was made in 1521, and was engraved on wood by Agostino Caracci in 1579. The three Magi are portraits of Titian, Raffaelle, and Michael Angelo.

While commencing the church of San Nicolo, at Carpi, our "painter architect" was called upon to enter a new sphere of action, and to bring to bear his engineering knowledge in planning and superintending the fortifications for the defence of his native city, Siena. Upon the completion of these works, Peruzzi again repaired to Rome, where, upon the death of Raffaelle in 1520, Leo X. appointed him architect to St. Peter's, when he was called upon to design a new model, upon which it is said he employed so much talent and skill, that even the fastidious Milizia considered it worthy of praise. Serlio (who was Baldassare's pupil) describes the plan to have been a Greek cross, terminated at each extremity by a semi-circular apse. There were four square sacristies, over which campanili could be erected. At each extremity of the cross was a semi-circular porch, through which, by three openings composed with four detached columns, was an entrance to the building. The great altar was in the centre, surrounded by four large piers, supporting a cupola 138 feet in diameter (within one foot of that since executed). Each of the four naves had two side aisles, with cupolas at their intersections 48 feet in diameter.

The tomb of Adrian VI. in the Chiesa dell' Anima, is the work of Peruzzi; and the Vigna of Papa Giulio, on the Flaminian way, although ascribed to Sansovino by Vasari, is considered by Le Tarouilly as the work of Baldassare. It is a most charming and elegant composition, and we are at a loss which to admire the most, the grace and simplicity of the whole, or the exquisite delicacy of the detail. Peruzzi's genius appears to have been nearly universal, for we next find him engaged painting two scenes for the representation of the "Calandra," a drama written by the Cardinal Bibiena, and performed before the pope: these scenes are said to have served as models for whatever has been since done of that kind. The preparations for the coronation of Clement VIII. were also entrusted to the care of Peruzzi in 1524. A small palace in the Via Giulia, at Rome, is also given to us by the indefatigable author of 'Les Edifices de Rome Moderne,' as the work of Peruzzi, and it presents an excellent specimen of the great extent to which external ornamentation was formerly carried. The decorations are described to have been in some instances in "fresco," and in others, painted in imitation of bronze and gilt, and portions are said to have been executed by Baldassare's own hand: they are composed in a grand style, and after the manner of the antique. The fresco figures were still tolerably preserved in 1823. The doorway under the vestibule of this palace is made to diminish in width upwards; the same method has been adopted by San Gallo, at the Palazzo Farnese: and upon this Le Tarouilly remarks, "that at this epoch (the XVIth century), when there was a general feeling for the antique, and when the cultivation of the ancient art had become as it were the true religion among all the professors; when learned commissions were instituted to make commentaries upon Vitruvius, it is not to be wondered at, that the two eminent architects, Peruzzi and San Gallo, studying together the ancient monuments, should about the same time have made the same application from what they had studied."

About this period Peruzzi executed the beautiful altar, and the chapel of St. John the Baptist, in the cathedral of Siena. The villa Belcarro, near that city, and the fine portal of the Sacrati Palace at Ferrara, were also designed by him at this date, and it was probably about this time that he painted his celebrated picture for the church of Fonte Giusta, at Siena, representing "the Sibyl announcing to Augustus the birth of Christ," which is said to be his masterpiece. So highly was this picture esteemed by Lanzi, that he says, "the painter gave it so divine an enthusiasm, that Raffaelle, treating the same subject, as well as Guido and Guercino (whose Sybils are so often met with) probably never surpassed it." Forsyth describes this picture in the following terms: "Peruzzi's Sibyl at Fonte Giusta is a sublime figure, but, perhaps, too sedate for the act of prophecy." We now arrive at the greatest as well as the last and crowning work of Peruzzi, the pyramidion of his fame—the celebrated Palazzo Massimi.

The architect to the Massimi Palaces, in the adaptation of his plan to the limited and perplexing site, and the obligation to preserve existing foundations, under injudicious notions of economy, had no common difficulties to contend with; but the genius and invention of Baldassare overcame all obstacles. The curved line of the frontage, which would have been to many a "pons asinorum," was rendered by him a "pons triumphalis."

Many of the Roman palaces are upon a larger scale than this, and are more imposing in their exterior architecture, but I doubt whether for beauty and grace of ornamentation any can compare with the Massimi. The strict injunctions to economise prevented Peruzzi from employing any expensive or rare materials, for, with the exception of two marble columns only, in the loggia of the Piano Nobile, the construction is of Travertine stone, of brickwork faced with stucco, and of wood. This example is cited as a lesson of economy; and when we consider that the exquisite enrichments derive all their beauty and elegance from the masterly design and execution, without any aid from expensive materials or costly adjuncts, we may well join in the homage that has been bestowed upon Peruzzi by French architects. I have already had occasion to remark that more than three centuries have elapsed from the period of building the Massimi palace to the time when Le Tarouilly was engaged in carefully measuring and taking note of every portion still remaining, and at the date of his labours, some thirty-five years since, when I had the gratification of being in Rome, the Massimi was generally in a fair state of preservation; but I am grieved to say that it now no longer remains so, for my excellent friend and our esteemed brother Fellow, Mr. John Davies, who last year made a pilgrimage to Italy, and revisited the scenes of his early studies after an interval of some thirty-seven years, thus describes the present state of the palace: "When I was in Rome, in October last, I went all over the Massimi, and was grieved to see the shameful state in which it was, the beautiful open vestibule and ceiling next the street falling to pieces." Le Tarouilly concludes his notice of Peruzzi in these terms: "It was about the year 1532 that Peruzzi commenced the Massimi palaces, and at that period he was in the full energy of his talents. The taste and infinite variety he has displayed in the ornamentation are a proof how well he accomplished the work studied by him in the most minute details. Poor Peruzzi died in 1536, at the age of fifty-five, in a state bordering upon misery. We cannot be altogether surprised at this melancholy termination he had to labour for a numerous family, and his income was never proportionate to his merits or his services. According to Vasari, the rich personages who profited by his talents took advantage of the gentleness of his character, his modesty and extreme reserve, and they thought less of recompensing the artist, than they did of praising his works.

Peruzzi's most distinguished pupil was Sebastiano Serlio, who was twenty years of age at the time of the lamentable death of his unfortunate master. Serlio remained in Italy three years after this event, and then proceeded to France; where he executed, together with Pierre Lescot, Jean Bullant, and Philibert Delorme (all worthy students of the same school) some of the finest works in architecture that France possesses of that period, and it is I believe principally owing to the careful study of the works of such master minds as Vignola, Peruzzi, and their disciples, that the French architects have acquired that exquisite taste in orna-

Digitized by Google

mentation so prominent in all their works. It is to the same pure sources that I would most earnestly entreat the students of our own country to have recourse, looking forward to receive the grateful tribute to talent by their brother architects, as in the distinguished instance we have had before us this evening, rather than being deterred by reflecting on the misfortunes sometimes attendant upon genius, as in the case of poor Baldassare Peruzzi.

INSTITUTION OF CIVIL ENGINEERS.

J. Locke, Esq., M.P., President, in the Chair.

April 12.—The whole of the evening was occupied by the discussion of Mr. McMaster's paper, "*On the Permanent Way of the Madras Railway.*"

It was remarked that, for India and other similar countries, the ordinary chair-and-sleeper road was not yet ascertained to be the best that could be adopted. In such cases it was desirable to aim at obtaining the smallest number of pieces, simplicity of parts, and avoiding complicated fittings. The arrangements should be made with a view to guard against peculation, as well as to the best mechanical construction; for the natives were apt to steal fishing plates and bolts. It was contended that the single-headed rail, fixed directly upon the sleepers, and with a sufficiently broad flange to prevent injury to them, was preferable. This form of rail had been extensively used in Germany and the United States of America, and the application of the "fish" rendered the joints much more secure and the surface more uniform. It was urged that the quality of the materials and the machinery to be sent to India and other distant places should be carefully attended to, as the heavy charges for freight and shipment formed a large portion of the expense. In this view it was thought that the double-headed rail first introduced by the President, provided that it was so laid as to be capable of being reversed, possessed great advantages. It was believed that rails weighing 60 lb. to the yard, to which an additional hammering had been given during the process of manufacture, would answer well for lines where very high speeds were not essential, and that their use would be attended with economy.

Allusion was made to a system of enabling the double-headed rail to be used without chairs. This was by suspending the rails between a pair of longitudinal balks, contoured to the rail channels. The rail and timbers were bolted together by flat bolts, 3 feet apart. The joints of the rails were connected by brackets of angle iron to a cross tie of timber. By this plan a thinner web could be used, and therefore a deeper rail for a given weight. When it was wished to reverse the rail, it was not necessary to disconnect the rails and the timbers, but merely to take out the joint bolts. It was believed that this system would induce economy, as no chairs were used, and less timber and ballast would be required than on an ordinary cross-sleeper road. A length of 150 yards of this way had been laid for six months on the main Cambridge line, at Stratford, where the ballast was bad and the traffic great. The timber used was only cross-sleepers cut down the middle. It made a good road, and there was a perceptible difference in passing on to it from the other portions of the line.

It had been stated that the compressed keys were liable to shrink in hot climates, and that some which had been allowed to remain on the sea coast in India had swollen so much as to be unfit for use. On the Lisbon and Santarem Railway, an oaken key 10 inches in length and slightly tapered had been substituted; and this plan was about to be tried on the Madras Railway. The employment of an iron key, with a thin cushion of wood between it and the chair, the timber being cut across the grain, was suggested as an alternative. In defence of compressed keys it was remarked, that what had been stated was scarcely so much the necessary cause of the defect of the key, as the way in which the keys were used. Twenty millions of these fastenings had been supplied for the railways in India, or sufficient to lay 2200 miles of road, and no complaint had ever been made until quite recently. The author of the paper had said, that the compressed keys lasted better than those which were unprepared; and it was also believed that the loss from premature expansion had been inappreciable during the period of three or four years during which they had been used on the Madras Railway. But being aware that the amount of dry heat to which they would be subjected, with iron on both sides of them, might have a tendency to cause even compressed keys to shrink, until they were thoroughly saturated with moisture, they had lately been made larger than usual, so as to receive a greater degree of compression. It was understood, that hundreds of casks of keys had been lying exposed to the heat of the sun for months after their delivery in India, and until the staves of the casks opened. If there had been any expansion of the tightly packed keys, the casks would have been burst open. With proper care however it was maintained that they would have remained without fault.

It was thought that one of the main points arising out of the paper was, whether it was desirable to construct permanent way in India with timber or with iron sleepers. As the cost of renewal irrespective of ordinary maintenance amounted on lines in this country to £100 per mile per annum, of which sum about 37 per cent. was for the renewal of the rails, and 63 per cent. for the substructure, attention had been directed to the use of cast-iron for sleepers, which had been proposed and tried in many different forms. In Egypt, Greave's spheroidal cast-iron sleeper with the chair cast upon it had been found best suited to the soil and climate. There was little or no ballast on the course of the line, so that it would have been difficult to have found a foundation for the ordinary sleeper. Trough sleepers of cast-iron, in which the rail was suspended between linings or cushions of timber, so that in the case of the double-headed rail the lower table was not injured, and the rail could therefore be reversed, had been in use for nine years on the Eastern Counties, and for two years on the South Eastern and the Midland Railways. In the latter case they were laid near to the Derby station, where they were subject to a traffic of 550 engines, 2400 waggons, and 120 carriages, every twenty-four hours. A modification of these two forms, which might be denominated the "cup-trough," had recently been proposed, in which the chair was entirely dispensed with, so that there were no projecting parts liable to fracture. Tie-rods passed through the neutral axis of the rail, with square washers of unequal thickness placed in the side channels, secured both the angle and the gauge. This form of sleeper was stated to be applicable to any ordinary section of rail, without alteration of pattern; was said to be inexpensive in manufacture, and to be easily maintained, as it was packed through dorner holes at the sides, which were believed to afford greater facility than holes at or near the top. For shipment they could be stowed into one another, and save space. It was assumed that the first cost of a substructure on this system would amount to £910 per mile of single way, and on the ordinary system to £551 per mile, taking the cross sleepers at 4s. each, and the chairs at £4 10s. per ton. But it was contended that the timber sleepers would require to be renewed twice in twenty-one years; for although the timber might be rendered chemically durable, the destruction would go on nevertheless, and when the time arrived for the renewal the timber would be valueless, whilst the cast-iron would be worth two-thirds of its original value. It had been estimated that the saving, by the use of iron, would amount to £1058 per mile of single line, in a period of twenty-one years, after allowing interest for the original outlay in both cases.

In regard to the durability of timber sleepers, it was asserted that when properly creosoted they lasted much longer than would be inferred from the comparison just made. Scotch fir sleepers, laid on the Eastern Counties in 1841, had remained perfect to the present time, not one having been removed on account of decay. Between the years 1840 and 1842, creosoted sleepers had been laid on the Manchester and Crewe, which were still sound; and indeed, in re-laying the line with heavier rails two years back, some sleepers that had been in wear sixteen years were employed. The sleepers for the East Indian railway were weighed previously to being placed in and when taken out of the cylinder, in which they remained twenty-four hours under a pressure of 124 lb. to the inch, in order that 10 lb. of creosote per cubit foot might be forced into them. Some triangular creosoted timbers, which had been sent to India, had shown symptoms of decay, due, it was believed, to their being of hard wood, and to the form not being the best for the purpose, as the angles were liable to be damaged, and thus expose the uncreosoted portion of the wood. Timber should be stacked and properly seasoned before being creosoted, and it had been found that heart-wood was not so easily creosoted as young sappy wood, as it was impossible to make it absorb the necessary quantity to preserve it thoroughly. In the latter case, after a few years the creosote set into a solid bituminous mass; but only the thin and volatile portions entered heart-wood, and these were liable to evaporate quickly when the sleepers were used in a hot climate. Specimens of sleepers which had been "Burnettised" in 1841, and laid at that time on the Eastern Counties Railway, were shown to be quite sound at the present time. With respect to unprepared wood, instances were given of the sleepers having been said to have lasted many years, but the evidence was not conclusive. It was stated, that good sound larch sleepers were in some cases preferable to Scotch fir that had been creosoted, and that it would last equally long. It was observed that it was impossible to subscribe to the principle which had been advocated, that wood of the lowest quality, or young timber full of sap, and which sucked up a large quantity of creosote oil, should be selected for use, because it was favourable for creosoting. It was believed that the best results would be obtained when the utmost care was taken in selecting the woods. A good result was tolerably certain under these circumstances, and in corroboration it was mentioned, that timber laid in 1835, some of which was Kyanised, although the preparation merely entered to the depth of one-tenth of an inch, and some of which was unprepared, had lasted to the present time. St. John's yellow pine had been proved to be one of the most durable woods, both for railway sleepers and marine works. At the Liverpool and Sunderland Docks there were instances of its being quite fresh after being in use twenty years.

With regard to marine works, it was said that the worm would not touch timber which was creosoted to the depth of two or three inches around the pile. When however this coat was cut through, the worm would penetrate into the heart-wood, but when it reached the creosoted portion, it was stopped by the objectionable nature of that material. This had been proved to be the case at Lowestoft, where the creosote

Digitized by Google

was found to be generally a preservative against the ravages of the worm. In all cases the timber should be cut for framing before being creosoted. It was remarked that, although in general creosoting doubled the duration of the timber, yet the creosoted piles of the pier at Leith showed symptoms of being attacked by the worm. An instance was also mentioned of the worm penetrating a balk of creosoted Memel at Scrabster, Caithness, and having eaten through the blackened portion, although the pile had been in the sea for less than six months. To this it was replied, that the discolouration of the wood afforded no correct test of the timber having been properly creosoted; and it was suggested whether the work of destruction might not have commenced before the balk was creosoted, as there was hardly a log from Memel which was not more or less penetrated by some kind of worm. Kyanising was asserted to have no effect, as the corrosive sublimate combined with the sap of the wood, and formed a substance which was not poisonous, and could be eaten by the worms with impunity.

It was thought that sufficient stress had not been laid on the importance of utilising as far as possible the resources of the country in which the works were being carried out. In Ceylon, for instance, there were forests of almost interminable extent which might be made available. Eighteen different samples of timber had been examined, at least nine of which were applicable for railway sleepers in situations where they would be exposed to extreme variations of atmosphere and weather. The drainage of railways in tropical climates was a matter of the utmost importance, as the ballast was liable to be carried away by the heavy periodical rains. In reply it was intimated that the necessity for sending out timber sleepers to India arose from the circumstance that the supply there could not be relied on. There was great difficulty in determining the precise value and quality of woods in foreign countries, especially when such practices were carried on as steeping the wood in order to deceive, as had been the case in Madras.

In closing the discussion, the great diversity of opinion that still prevailed on this subject was commented upon. Every one appeared to think his own plan the best, and naturally preferred to be guided by his own experience rather than by that of others. As to the question of the durability of timber whether prepared or not, and, if prepared, then by what process, few persons were able to obtain reliable data as far back as twenty or thirty years. The Minutes of the Institution would contain a variety of opinions on this subject, but it was doubted whether the question could be solved, or whether there could ever be universal agreement as to what was the best system of permanent way to be used under all conditions.

After the meeting, Mr. Curtis explained a system of axle boxes, in which by centrifugal action the oil was constantly thrown over the upper side of the axle, and descending slowly upon the axle was returned again to the oil chamber. As soon as it had passed the axle, a piece of thin porous flannel placed at the bottom of the oil chamber was found in practice to answer as a filter to receive the parts of the metal, or other residuum resulting from the working of the boxes. These boxes were now at work on eight railways in England and on one in France. They had been in use for upwards of eighteen months; in some cases they had run for two months without any oil being applied; but the ordinary practice was to introduce about a wine-glass full of oil to each box once a week.

April 19.—The paper read was "*Description of the Entrance, Entrance Lock, and Jetty Walls, with the Wrought-iron Gates and Caisson, &c., of the Victoria (London) Docks.*" By W. J. KINGSBURY, A. Inst. C.E.

This paper had chiefly for its object to bring forward an account of some special works, which from their magnitude and peculiarity presented novelty and interest; it was therefore rather a contribution to the history of the Victoria Docks than an attempt to convey a complete idea of that undertaking.

The Victoria (London) Docks were briefly described as being situated in that part of the Plaistow Marshes, Essex, which, projecting forward towards the south-east, was bounded on three sides by the river Thames, which there formed a loop or bend, extending from Bugsby's Reach, just below Blackwall, to Galleon's Reach, below Woolwich.

The entire area comprised within the dock was shown to be about 200 acres, of which one half, or 100 acres, was water space. This consisted of the entrance, with its lock,—the tidal chamber of 16 acres, and the main dock of 74 acres. In general terms, the basin and dock together were 4050 feet in length and 1050 feet in width at the level of high-water mark.

In addition to the quay room afforded by the sides of the basin and dock, four jetties, each 581 feet long and 140 feet wide, were projected from the north side into the dock; these jetties, with the sides of the dock and of the basin, provided a length of three miles of quay space.

The general surface of the original marsh land was about 8 ft. 6 in. below Trinity high-water mark; and the tidal water of the Thames was always excluded by an embankment, which was maintained at a height of 5 feet above T. H. W. M.; that level was therefore adopted for the top of the copings of the entrance and of the lock walls. Taking T. H. W. M. as the datum, the bottom of the docks was stated to be 24 feet below datum,—the depth on the upper gate cill 25 ft. 6 in., and on the lower gate cill 28 feet, which latter depth was maintained throughout the entrance from the river; and as the mean fall of tide was 18 feet, there was a depth on the lower gate cill of 10 feet, and on the upper gate cill of 7 ft. 6 in. at Trinity low-water mark.

The subsoil was described as consisting of beds of yellow and blue clays, of varying thickness, and of a total depth of 5 or 6 feet, then a depth of from 5 to 12 feet of peat, and then a good bed of gravel overlying the London clay, which was found throughout the length of the lock at a nearly uniform depth of 37 feet below T. H. W. M.; and on this foundation, at a depth of 37 ft. 6 in., both the upper and the lower gate platforms were laid.

The sides of the entrance of the channel leading to the tidal basin and of the lock, were composed of concrete walls, faced with cast-iron piles and plates. The main piles were driven at intervals of 7 ft. 1 in. from centre to centre, the intervening space being filled by cast-iron plates, whose lower edge rested on the upper end of four cast-iron sheeting piles, which with them occupied the entire space between each pair of the main piles. These latter were each in two lengths; the lower 25 feet, and the upper 12 ft. 8 in., and the metal was about 2 inches thick, cast in a trough form, 18 inches in width. The sheeting piles were each 20 feet long, of similar form; the three interspacing iron plates for every bay were each 5 ft. 11 in. wide, and 5 feet deep, cast with back feathers to give the necessary strength, and provided with a top flange to carry the stone coping of the wharf. In the rear of each main pile, and at a distance of 18 feet from it, a timber land-tie, 20 feet long, was driven to a proper depth, and secured to the iron piles by two eyebolts and nuts, and behind them a wall of concrete was filled in, varying in thickness from 12 feet to 6 feet at the top, where the stone coping of the wharf was laid. The main piles were driven 5 feet into the ground, and the sheeting piles about 2 ft. 6 in. into the same stratum. Clay puddle and concrete were also used to render the lock chambers perfectly sound.

As the London clay was met with at a depth of 37 feet below T. H. W. M., advantage was taken of the circumstance to dispense with an invert at the gate platforms, by substituting ordinary brickwork. This was accomplished by laying open, down to the clay, the necessary areas for the upper and lower platforms—surrounding them by single rows of elm sheet piling 16 feet long and 9 inches thick, driven close, to a depth of about 7 feet into the solid clay; these were secured by walings, and within the spaces so secured the brickwork of the platform was laid. In this mode of construction it was essential to take out all the gravel; to lay the bricks directly upon the clay, and to use close piling, in order to prevent the possibility of any water getting beneath and blowing up the brickwork. Upon these platforms the side walls, which were 20 feet in thickness where they joined the concrete walls, were carried up in brickwork.

The hollow quoins for the gates, the external arris of the gate recess, the caisson quoins and cill, and the copings and bedstones for the anchors, which constituted the bulk of the stone work employed, were of a compact sandstone, called Duke's Quarry stone. The bricks used were almost all made from clay excavated from the site of the docks, laid in mortar composed of Halling lime and clean sharp sand; the latter also from the excavation, whence the gravel and sand used in the concrete also proceeded; so that these essential ingredients for the structure were found on the spot.

The paper then described the sluices and the pipes for filling and emptying the lock, with the precautions for examination and repair, and in general it appeared that every facility was provided for access to every part liable to wear and tear or injury, and for remedying all defects.

The cost of the piled and concrete wall of the lock chamber was stated to be £17. 0*s.* 7*d.* per foot run, and that of the entrance to be £19. 5*s.* 10*d.* per foot run, or £51 and £58 per yard run respectively. The price of the cast-iron at the time of the construction of the docks was £6 per ton; and the weight of iron averaged about 1¼ ton per foot lineal of the wall.

A description was then given of the three pair of lock gates—viz., the lower and upper gates of the entrance lock, and the inner gates separating the tidal basin from the main dock. All these were constructed of wrought-iron, nearly alike in dimensions and general arrangements. The objections to the use of timber were enumerated,—the introduction of cast-iron ribs, with timber planking, was noticed; and the gradual employment of wrought-iron for the frame, the plating, the diaphragms, and all the parts except the heel and mitre posts, was described. It was shown, that on account of the large dimensions of these gates, and more particularly their amount of curvature, timber would have been inapplicable; the lower gates being 80 feet in the span by 31 feet in height, with a versed sine of 20 feet, or one-fourth of the span. The form of the outer curve of the gates was an arc of a circle, having a radius of 50 feet; the distance between the skins, at the heel and mitre posts, was 2 feet, and at a point midway between them 3 feet, the inner boundary being two arcs of circles struck from centres 9 ft. 5½ in. apart, with a radius of 59 ft. 9½ in. There were fourteen horizontal diaphragms in each lower gate, the distances between them varying from 1 ft. 11 in. at the bottom, to 3 feet at the top. Beneath the bottom plate, which was ¾ inch thick, a piece of timber to meet the shutting cill was fixed by bracket pieces. The horizontal diaphragms generally were ½ inch thick, and were attached to the skins by T and angle irons. There were also two vertical dia-

Digitized by Google

phragms passing continuously from top to bottom, and dividing each gate into three equal parts. These tended to prevent twisting, and added strength to the structure. The outside plating varied in thickness, according to the strain to which it was subjected, from ⅜ inch at the bottom to ⅝ inch at the top. The plates were disposed with their lengths vertically, and all the joints were provided with strips on the outside and on the inside, to render the structure watertight.

The heel and mitre posts were of green-heart timber, and were firmly attached by angle irons and bolts to the gates. The chain attachments were made to draw upon both skins and upon the entire frame of each gate, and to be accessible at low water. The gates were opened and closed by Armstrong's hydraulic machinery.

The peculiar arrangements for the moveable handrails of such curved gates were then described; and it was shown, that by the use of swivel sockets the curved rail could be made to shut down quite close, to permit the passage of the towing ropes.

The pivots and foundations were then described, as were the shutting cills, with the means of securing them, the roller paths, and the rollers, the latter demanding peculiar arrangements, on account of the curved form of the gates and their great weight. They were so arranged as to be easily accessible outside the gate, and by releasing a nut the column which fitted into a recess in the upper part of the roller-frame could be removed, and the roller could be drawn up by chains in the guides, be examined and repaired if necessary, and be restored to its place, without disturbing the gates.

The large anchors were also fully described, as were the modes of securing them.

The upper and inner gates were stated to be somewhat lighter than the lower and outer gates, the material was thinner, and there were fewer horizontal diaphragms; in other respects all the gates were nearly identical. The inner gates were not worked by hydraulic power, and the sluicing was done directly through four apertures in each of the gates themselves, instead of through the side walls.

The weight of metal in the gates was—

Wrought Iron.

	Tons.
In the inner gates, including the cast-iron pivot stop piece... ...	198
Ditto in upper gates	128
,, inner gates ... ... (including sluices)	138

Cast Iron.

In the shutting cills, pivot crosses, anchors, rollers, roller paths, foundation plates, &c., with the bolts for each pair of gates ...	59

The ancient river bank, which was about 5 feet above T. H. W. M., and protected the marsh from the overflowing of the river into the low district, formed a natural dam, behind which the inner works of the lock chamber, the brickwork of the gate openings, and the other operations were carried on, and outside of which a considerable portion of the piling and the concrete walling was executed. But in order to effect the junction of the two portions, and to complete the entrance works, it was necessary to remove a large quantity of material by barrow, and then to resort to dredging below low-water mark. To admit of this being done simultaneously with the other works of the dock, it was essential to provide the means of keeping the water out of the dock whilst the river bank was broken through and carried away. A coffer-dam would have been expensive and tedious; recourse was therefore had to a caisson, which was constructed of wrought-iron plates, and from its great size and the peculiar mode of using it the description became very interesting. The ordinary form of a caisson was well known to be something like that of a ship, with a raking stem and stern, and fitting into grooves in the side-walls, whilst the keel applied itself close down against a shutting cill.

The new caisson was built of a rectangular form in its side elevation, the heel-posts being vertical and shaped like those of the gates, so as to fit into a hollow quoin, as into a kind of rebate. In plan it was similar to one leaf of the gates, being 3 feet wide in the middle and 2 feet at each end, and it was large enough to extend across the span of 80 feet between the lock walls; its curvature was not great, the rise or versed sine being 8 feet, the outer and inner curves being struck with radii of 94 ft. 8 in. and 104 feet respectively. The height of the caisson was 31 feet, and there were five horizontal close diaphragms in that height, including the bottom and top plates. It was thus divided into four spaces, the lowest of which was 4 ft. 1 in. high, the second was 9 ft. 2 in. the third 10 feet, and the fourth or upper space, 7 ft. 9 in. There were also two vertical diaphragms from the bottom to the top. The position of the lower horizontal diaphragm was designedly fixed, so that the internal capacity of the bottom space should be equal to 25 tons of water. There was a bottom lining piece of Memel timber to meet the shutting cill. There were also two rectangular sluices, one opening through the bottom lower compartment, by which the water could be admitted to fill the dock; and another of small area on the concave side, opening into the lower compartment, by which it could be filled when required. A three-throw pump, with gearing for emptying the caisson, was fixed on the top.

The hollow quoins for the caisson were built of Duke's Quarry stone, and were placed in the walls where they began to rake back from the perpendicular to meet the batter of the piling.

In using the caisson, its total weight being about 90 tons, if the water-space was pumped out it would float with the convex side downwards, nearly in a horizontal position. On the small sluice being opened, the water entered the bottom compartment, and caused the caisson to tilt gradually into a vertical position, during which time it was drawn towards its position between the quoins and the heel-posts fitted into them. Thus, with a caisson of this form and construction, no greater depth of water than just enough to float it was required to get it out of its place; and as soon as it was free from the quoins it could be turned on its back, so as to present very little surface to the wind, and in that position it was perfectly manageable.

The construction of the jetties, which had been already incidently noticed with regard to their position and general dimensions, was then described. The general form was that of a parallelogram, 497 feet long and 140 feet wide, terminated by a pointed end, the sides of which were 109 ft. 6 in. long, and met at an angle of 80°, making the extreme length 581 feet. The height of the quay was 6 feet to 9 feet above T. H. W. M., according to the situation of the jetty in the dock.

On the jetty a warehouse was built, 500 feet long and 80 feet wide, consisting of vaults and two floors, of nearly an acre in extent each. The outside space of 30 feet on each side to the edge of the quay was appropriated to railways and the temporary storeage of goods. Facilities for discharging and arranging goods were provided by hydraulic cranes; one capable of lifting 5 tons with a range of 31 feet being placed at the pointed end, and eight others, arranged in pairs, sweeping outwards from 21 feet to 23 feet, and capable of lifting 2 tons each, were placed at intervals on the sides of the warehouse. There were also turntables and sidings, for the purpose of collecting and distributing the waggons on the main line of railway leading from the docks.

The side walls were described as a combination of cast-iron piles, vertical brick inverts, and concrete, with a backing of clay.

The piles, which were T shaped in section, and 35 feet long, weighed about 1¾ ton each. They were driven to a depth of 28 feet below T. H. W. M., at intervals of 7 feet. Between them the brick inverts, which were 14 inches thick, were filled in; and behind this the concrete was carried for an average thickness of 3 ft. 6 in. The piles were connected to each other across the jetty by two tiers of tie-bars, 2 inches in diameter, and 12 feet apart; the upper one being placed 5 feet below the heads of the piles, and by means of them the piles were secured from being forced outwards, and could be adjusted in line. The bottom of the wall was commenced 1 foot below the bottom of the dock, and the wall itself was considerably strengthened at the pointed end, to enable it to bear the blows to which it was exposed, and as a foundation for the 5-ton crane. The top was finished off with a cast-iron capping and wood cill secured to the heads of the piles; and the upper surface of the jetty was ballasted, and some portions planked. As a precaution, the angle formed by the upright face with the floor of the dock was filled to some height with clay puddle, to prevent the passage of water under the wall.

The total cost of each jetty, exclusive of the warehouse and cranes, was £12,000, or £10 per foot run of the quay.

It was noticed that an incident which at first threw some doubt on the capability of the walls to resist the passage of water, was afterwards satisfactorily accounted for. It was explained that the floor of the vaults under the warehouses was about 2 feet 6 in. above the marsh level, and 6 feet below that of the water in the dock at T. H. W. M. When the water was first admitted it appeared in the vaults, and it was found necessary to remove it by means of drains. This, which was supposed at first to result from leakage either through or under the walls, was soon found from its containing iron to be water from the gravel, which in this district rose to within a short distance of the surface, and in this case gained access to the vaults by means of the concrete walls of the warehouse. The discharge from the drains was now very slight; the diminution being attributable to the consolidation of the ground against the walls, and to the silting up of the porous materials, by the rusty deposit found in the water. It was remarked in corroboration of this explanation, that quite recently the discharge from one jetty entirely ceased during the time that the level of the water in the gravel was kept down by pumping to get in the foundations of a new warehouse in the immediate vicinity, but was re-established shortly after the pumping was discontinued.

The casualties which occurred during the construction of the dock were fully described; these were comparatively few for a work of such importance.

The first, which was a fracture of the cast-iron shutting cill, arose from the subsidence of the ground under the heavy side walls being greater than that of the brick platform to which the shutting cill was bolted down. The side walls subsided about 1¼ inch, and in consequence the cill was cracked near the centre. The defect was soon discovered and as speedily remedied, by bolting a plate of wrought-iron on the back of the cill. This accident pointed out the importance of allowing the side walls to settle before the holding-down bolts of the cill were finally tightened.

The next casualty occurred in the lock-chamber, where, without any premonitory symptoms of weakness, and almost simultaneously, both sides of the chamber between the upper and lower gates moved bodily forward,

Digitized by Google

pushing up the thick puddle towards the centre, bending and breaking the tie-bars behind, and dragging the tie-piles forward, fracturing several of them, whilst however the brick side walls of the gate platforms remained entirely uninjured. Very energetic measures were adopted for reinstating the walls. The old concrete was cleared away, the iron piling was driven 10 feet lower than previously, the sheet piles entering 5 feet into the clay; in which a solid concrete wall was commenced at a depth of about 5 feet, and was carried up for a height of 18 feet, with a thickness also of 18 feet, above which it was reduced to 10 feet in thickness, with counterforts projecting 6 feet, with a breadth of 6 feet, and at intervals of 10 feet, nearly to the top of the piles. On this mass of concrete a brick wall was built, 10 feet high, averaging 4 ft. 6 in. in thickness, with counterforts 3 feet square and at intervals corresponding with those below. The piles were secured to the concrete walls by means of iron rods passing through them to cast-iron plates, to which they were screwed up tight at the back. The clay puddle was removed from the bottom, and was replaced by a mass of concrete, with a top layer of Portland cement concrete 6 inches in thickness. The damage was completely repaired in three months, and no signs of weakness were subsequently perceived. This casualty was accounted for by the previous draining of the ground all around, due to the constant pumping during the progress of the works; and on the cessation of this process the water rising behind the walls occasioned additional pressure, which forced the sides inwards. That the failure resulted from this cause was demonstrated by the fact of the movement of the two sides being nearly simultaneous.

The next casualty which occurred was the fracture of two of the pivot castings of the lock gates. This was shown to have arisen from the binding of the brass socket upon the iron pivot, so that the pressure, instead of being distributed over the whole area of the step, was restricted to a comparatively small annular portion; thus the brass "seized" or adhered to the pivot to such an extent, that the gate, instead of working upon the pivot, turned upon the brass, and burst the sides of the box in the effort to free itself. At this period also the gates were leaky, in consequence of some of the joints not being tight, and the weight upon the pivot being much increased. The mischief was aggravated by hydraulic power being employed to open and shut the gates, and thus the undue resistance was not so soon perceived as if capstans worked by manual labour had been employed for a short time after the completion of the gates. This course was recommended as a prudent precaution in similar cases. The cause of the casualty being ascertained, the remedy was easy, and was speedily applied.

The last casualty was the splitting of the roller path, which was a direct and intelligible result of the previously mentioned leakage having rendered the gates so much heavier than the casting had been intended to bear. This was remedied by rendering the gates water-tight; and in putting down a new path the surface for the roller was made 7 inches wide instead of 4 inches, and no difficulty has since been experienced. These casualties were very fully detailed, as being perhaps more useful than any other part of the paper.

The latter portion of the paper was on some advantages of the form adopted for the Victoria (London) Dock Gates, with respect to economy of material and general arrangement.

The term cylindrical, or gates of continuous curvature, was adopted to distinguish them from those formed like a gothic arch, and was employed to denote that the outer or convex curves constituting both leaves were struck from one centre, or formed portions of one and the same circle. The inner boundary was formed in the same way, or not differing materially from it.

Before proceeding to compare this form of gate with that of straight gates meeting at an angle, it was stated that no advantage was claimed for the former in respect to the amount or direction of the strain brought on the lock walls, but in regard to the section of the gate itself, even in ordinary cases, there was believed to be considerable superiority.

A few preliminary remarks were then made on the strains to which these structures were exposed; that in the cylindrical gate a compressive strain was induced by the pressure of the water, which was uniform on every radial section in the same horizontal plane (though of course varying with the depth); while in the straight gates meeting at an angle there were two strains, first, a transverse strain caused by the pressure of the water, and similar to that on a girder uniformly loaded, and, secondly, a compressive strain, arising from the pressure of the other leaf on its extremity. The compressive strain on any horizontal section of the cylindrical gate was stated to be equal to the pressure on the unit of surface multiplied by the radius of curvature, as shown by Prof. Barlow (*vide* Trans. Inst. C. E. vol. i. p. 133). The important distinction between the two kinds of strain to which straight gates were exposed was pointed out by Mr. P. W. Barlow, M. Inst. C. E., in his paper on Lock Gates, at page 67 in the volume already cited.

Some examples were then given, showing that this compressive strain in the straight gate varied very considerably, according to the ratio of the height or versed sine to the span; and consequently the importance of providing sectional area to meet this, as well as the strain induced by the direct action of the water on the leaf itself. With regard to the distribution of this strain in the two skins, the problem was not capable of accurate solution, in consequence of several practical modifying circumstances, but it was thought sufficient for the purpose of comparison to assume the equal distribution, especially as that view was in favour of the straight gate.

Some examples were then given in detail, for the purpose of instituting a comparison between the weights of gates required for spanning the same opening with the same rise or versed sine when made in the cylindrical form, and also with straight leaves meeting at an angle. The results were shown in the following table:—

Ratio rise to span.	Vertical angle.	Transv. strain in centre.	Compres. strain due to op. leaf.	Straight Gate.		Cylindrical Gate.	
				Mean section.	Quantity of material.	Mean section.	Quantity of material.
1 to 10	157° 22′	69·32	102·0	29·6	1207	26·0	1066
9	154° 58′	69·94	92·3	28·4	1164	23·6	975
8	151° 26′	70·82	82·5	27·25	1123	21·25	885
7	148° 10′	72·08	72·9	26·25	1092	19·0	801
6	143° 8′	74·06	63·3	25·3	1069	16·66	715
5	136° 24′	77·32	53·8	24·8	1011	14·5	640
4	126° 52′	83·33	44·7	24·9	1117	12·5	580
3	112° 38′	96·27	36·0	26·0	1250	10·8	552
2·66	106° 16′	104·15	33·3	28·0	1400	10·4	558

Some remarks were then made on several other practical advantages arising from the cylindrical form, in utilising sectional area, avoiding to a great extent unequal thicknesses of plates, and rendering the operation of caulking more easy and efficient. At the same time certain objections were mentioned, and it was stated that additional cost would be incurred in the manufacture of the cylindrical gates; but it was thought notwithstanding that the following propositions were fairly established:—

1. That a lock gate of the cylindrical form could be made with about half the quantity of material required for a straight gate.
2. That with the same ratio of rise to span, a saving of from 11½ to 55 per cent. might be effected in the skins alone, and that a further saving might be made in the horizontal diaphragm.
3. That by this mode of construction great facilities were afforded for rendering the gates watertight, and greater certainty be attained in accomplishing this very desirable object.

GEORGE P. BIDDER, Esq., V.P., in the chair.

May 3.—The paper read was "*On the Tyne Docks at South Shields, and on the Mode adopted for Shipping Coals.*" By T. E. HARRISON, M. Inst. C.E.

These docks had been constructed on the banks of the river Tyne, at the upper end of South Shields, on a large area called Jarrow Slake, which was covered with water at spring tides to a depth of from 5 feet to 8 feet. The area so covered amounted to about 350 acres, and of this quantity 179 acres were now inclosed. The area of water in the dock as executed was 50 acres, the depth of water being 24 ft. 6 in. at an average spring tide. The entrance basin was 9¼ acres in extent, with a depth of water of 25 feet for a width of 200 feet in the centre of the channel, gradually shoaling to the sides. One entrance had a width of 80 feet, and there was a lock 300 feet in length and 100 feet in width, with gates 60 feet in width; the cills in each case were laid 24 ft. 6 in. below high water of average spring tides—such spring tides having a lift of 14 ft. 6 in.

The total quantity of excavation in the docks was 1,783,452 cubic yards, and in forming the standage ground 281,305 cubic yards. The total quantity of masonry of all descriptions was 2,900,000 cubic feet. The cost up to the date of the opening for public traffic was £440,476. This sum included all the standage and railway approaches, the shipping jetties, the purchase of land, and all the dock-works, but it excluded parliamentary and other charges not engineering. The works were under the immediate superintendence of Mr. Robert Hodgson, as resident engineer; and the contract for their execution was let to Mr. James Gow.

The first point of engineering interest was the nature of the foundations. A series of careful borings showed, that though there was in places a strong stony clay resting on the coal measures, yet this clay was very partial, dipping suddenly away. Within a few yards of the clay-bed, borings were made to a depth in some places of 70 feet and upwards, through the mud or slake deposit, without getting a bottom; showing that not only the clay, but the coal measures, were gone. The original level of the ground was ascertained to be 10 feet below the lowest ebb of a spring tide at the present time, confirming the opinion that a general depression of the east coast had taken place.

The first operation in the construction of the works was to form a culvert, 5 feet in diameter, round the head of the dock area, to receive and carry off the upland waters. Dams were then formed of the materials from the excavations, consisting partly of clay and partly of slake, and after their completion the water was run off by sluices. Shortly after the first course of masonry of the foundations was laid for the north or 60-feet lock, the floor was observed to rise very regularly, about 3 inches

Digitized by Google

in the centre. A bore hole was then put down, when a strong feeder of water came away. The hole was therefore kept open during the progress of the works, and similar holes were made in other places. The flooring of the lock went back partially after the hole had been opened several days; and it was brought nearly to its original level by being weighted with stone.

In building a quay wall opposite the Jarrow Chemical Works, it was found that the slake would not bear the weight of the bank behind it, unless at a slope of 1 to 5. As so flat a slope was inadmissible, the plan adopted for overcoming the difficulty was by weighting the top with gravel, by which the toe of the slope was forced out. It was not until 150,000 tons of gravel had been deposited that the whole came to a state of rest. The slope was at present 1¼ to 1. It was pitched with stone, and rested at the bottom on a strong row of piles.

With a view of testing practically the sustaining power of the mud or slake, a bed of concrete 10 feet square was gradually loaded with iron, to the extent of 7 cwt. per superficial foot, without any settlement taking place; but as soon as that weight was exceeded the whole began to sink. The foundations of the timber jetties for the shipment of coals were therefore laid on a wide-spread base of concrete, with timber cill-pieces; care being taken not to exceed a weight of 5 cwt. per superficial foot. It was satisfactory to be able to state that there had not been the slightest appearance of settlement.

Immediately below the entrance to the tidal basin there was a canch of hard clay running out into the river. This had been entirely removed by dredging, and the flood and ebb tide now took their course as nearly as possible over the same channel, guided by the concave river wall. The latter was entirely constructed of creosoted timber, by means of one of Nasmyth's steam pile engines. A description was then given of this machine, which was so arranged that it formed its own roadway throughout; and it was remarked, that where there was a large amount of straightforward piling, or in cases of difficult driving, this machine was without an equal.

The dock gates were generally on the same plan as those of the Victoria (London) Docks. The only difference was that the Tyne Dock gates were curved both on plan and in section, the pivot of the heel-post being raised 3 ft. 6 in. above the level of the cill. There was thus less danger of anything lodging behind the heel-post, and the invert of the lock was carried right through from the end of the pointing cill. It involved however some large and rather intricate masonry, and necessitated great accuracy in fitting the doubly-curved wood cills to the doubly-curved masonry; but this had been successfully accomplished, and the cills were perfectly tight. One of the advantages in the use of wrought-iron for dock gates was that from their flotation the weight on the rollers might be adjusted at pleasure. The sluices were all made to work with brass against brass. The dock gates and sluices were arranged to be worked either by hand or by hydraulic power, the machinery for the purpose having been furnished by Sir W. G. Armstrong and Co.

The primary object of the construction of the Tyne Docks was to provide accommodation for the shipment of the large quantity of coals brought to South Shields, from the coal-fields of Durham and Northumberland, by the extensive system of railways belonging to the North Eastern Railway Company. The coal trade of the northern coal-fields had been gradually increasing for many years past; and in 1858 the quantity shipped at South Shields amounted to 1,203,524 tons, although the facilities were so limited that it was necessary to work night and day throughout the whole year. This was now wholly shipped at the Tyne Docks, and the work was generally done in fifteen hours.

A brief account was then given of the different methods of shipping coals used at the northern coal ports during the last forty-seven years. The system of "keels" was first described; and it was stated that it still existed to a limited extent both on the river Wear and on the river Tyne, in the case of those collieries not having direct railway communication to a place of shipment. Where the vessels could reach the shipping places, as at the Wall's End Colliery, the mode of shipment was by spouts, in general principle the same as those adopted at the Tyne Docks; but without for a long time any arrangement for allowing for the difference in the level of the tide and in the size of the vessel. The first innovation on the "spout" system took place in 1812, when a coal-drop was erected at Pelaw Main Spout, on the river Tyne, by Mr. B. Thompson, further improved by him in 1813, and since generally followed, with various modifications. The principle of all these drops was, that the loaded waggon in its descent raised a counterbalance weight; and when the coals were let out of the waggon, the counterbalance weight brought the waggon back to its previous position. The system of tubs fitted into "keels" in order to avoid the breakage of the coal was then alluded to, and the machinery by which they were transferred to the vessel was briefly described.

It was stated that after mature deliberation and careful examination of all the different plans, it was decided to adopt in the Tyne docks the system of shipping by spouts. The angle of inclination of the spouts was 50°, that having been found by experiment to be the angle at which coals would slide on smooth iron plates without rolling. In order to allow for the varying level of the ship's deck, which it was shown might amount under certain circumstances to 20 feet, arrangements were made to deliver the coals at four different levels. The coals were directed into any one of four divisions by the opening or shutting of trap doors, turning on hinges, and well balanced, so as to be easily moved. The spout was also raised or lowered in guides, and was operated by winches, the men standing on the level at which they worked when shipping coals. Traps were also provided for regulating the descent of the coals into the ship. In some cases the spouts were made to slide in a frame turning on a pivot, the object being to give a greater range into the ship's hold, particularly with screw colliers, and thus avoid the necessity of moving the ship. In practice the plan was to keep the spout nearly full, merely letting the coals slide sufficiently down to allow of the next waggon being teamed; so that although in the first filling of the spout, or on altering the level of the spout, the coal had a few feet to fall, yet this only applied to a small quantity of coal. Afterwards the whole mass slowly descended, and no further breakage took place.

Two jetties, on which there were twenty shipping places, were already at work. The shipping places were 100 feet apart from centre to centre, and were so arranged that the vessels overlapped each other. Arrangements were made so that the number of shipping places could be increased to fifty, as the trade required. In laying out the ground the saving of manual labour had been a primary consideration, and gravity had been called into operation to the utmost possible extent. The sidings into which the locomotive engines brought the waggons were on an inclination of 1 in 132. From these sidings the waggons were sorted by gravity into one or other of fourteen additional sidings, also on an inclination of 1 in 132, but at the curves and switches of 1 in 66. This sorting was effected by one man and one boy (who attended to the switches) for each jetty. When the waggons were wanted for shipment, they were brought out of the sidings, and descended by gravity, converging to one point, where there was a weighing machine; when passing over this machine at a rate not exceeding two miles an hour, the weights were easily taken. The lines then branched out again to the different spouts, the waggons being directed into their proper roads by switches, the working of which was attended to by one boy. There was a considerable amount of standage provided for each spout, and the length of single line of rails for each jetty was six miles. The standage was on inclinations varying from 1 in 32 to 1 in 100. Where the waggons descended from this standage to the spouts, the inclination varied from 1 in 20 to 1 in 87. The empty waggons were returned along two lines, one on each side of the jetty, having an inclination of 1 in 100. The impetus of the loaded waggons in descending carried them up this gradient, to or beyond the places where they were to be emptied, and when emptied gravity took them away. Experience had shown that twelve chaldron waggons, or six 8-ton waggons, might be taken down at a time. They were all run past the hopper, then dropped back by gravity, and were emptied three or two at a time, as they passed over the spout, without being uncoupled. Great expedition resulted from this arrangement; and on the day of the opening a screw steamer entered the docks, received on board 420 tons of coal in fifty-five minutes, and immediately went to sea.

In order to ship the quantity of coals now transferred to and being shipped in the Tyne Docks, there were employed last year at South Shields thirty-four horses and four pilot engines, and the work was carried on throughout the whole twenty-four hours. Under the present arrangement not a single horse was employed, and only two pilot engines, and the work was done generally in fifteen hours. At present there was rather a deficiency of standage for light waggons, but this was in course of remedy, and when completed no engine would be necessary. The cost of labour for carrying the coal along the jetty, a distance of 1050 yards, for the shipment, and for returning the empty waggons to the point where the engine took them up, was about seven-sixteenths of a penny per ton.

SUBMARINE TELEGRAPHS.

The great cost of gutta-percha—about 2*s.* 6*d.* per lb.—coupled with its now well-known deficiencies as an insulator, has roused the chemical world into efforts to discover some substitute which, while possessing all non-electrical and mechanical essentials, will at the same time relieve telegraph companies from the immense outlay now required for coating their wires with gutta-percha. Several experiments have been made with this object. Messrs. Silver and Co. have been foremost among the experimentalists, but instead of devising a new substance, resolved to trust the well-known properties of india-rubber, and with this view have coated several miles of wire with a double layer of that material laid on in spiral folds or bands, with their edges closely joined so as to be perfectly impervious to water at any pressure. Even at the present high price of india-rubber, wires can be thus coated at very little more than half the price charged for gutta-percha. The cost, however, is one of the least advantages of the material. India-rubber is almost as incompressible as water, and compared with gutta-percha requires a very high degree of heat to melt it, boiling water having no effect upon it whatever. Some lengths of the wire thus coated at Messrs. Silver's works have been

Digitized by Google

subjected in a hydraulic machine, for a considerable time, to a pressure of 7½ tons on the circular inch, and when tested, while still exposed to this pressure, the most sensitive of Mr. Henley's galvanometers showed the insulation perfect. An attempt to apply a higher rate of pressure than this terminated in the bursting of the hydraulic cylinder. When it is recollected that 5 tons pressure to the square inch crushes granite, it will be seen that a more complete test of the value of india-rubber as an insulator to resist pressure could hardly have been devised. The importance of its possessing this quality is far greater than would at first sight be supposed. A pressure of 7½ tons to the inch is equal to the pressure caused by the weight of water at a depth of eight miles. The greatest depth at which the Atlantic cable was submerged was three miles, and the weight of this mass of water upon the rope at the bottom of the sea was about 2½ tons. Gutta-percha at such a pressure is reduced to less than half its bulk. To this apparently insignificant fact it is possibly owing that the cable is now useless, for it follows, that when the core of the rope shrank to half its original diameter the outside wires stretched in proportion, while the gutta-percha could not but tear under the strain, and leave the conductor exposed in many places. The advantage, therefore, of india-rubber over gutta-percha in this respect is apparent, since it exactly reverses the unfavourable conditions of the latter, being incompressible and highly elastic. During the course of the experiments a considerable length of wire insulated with two coats of india-rubber was immersed in a large boiler of boiling water. Though the external part of the covering was boiled almost white, the insulation remained perfect. A similar length of wire coated with gutta-percha of the same thickness as the india-rubber was, of course, destroyed as a non-conductor immediately on its immersion, as gutta-percha melts easily at 100 degrees. It is true that submarine cables when laid are not required to encounter a heat of 212 degrees, but it is well known that while in process of manufacture, and especially when packed in ships' holds for the purpose of being submerged, they are often exposed to an amount of heat to which gutta-percha yields. This melting at a low temperature, together with the wire being badly centred at the Gutta Percha Company's Works, was a source of incessant anxiety to those on board the Agamemnon and Niagara during the expedition of last summer. The deck coils, from being exposed to the sun, were more liable than others to this danger, and some portions of them had to be cut out in consequence of the copper wire having pushed through the soft gutta-percha. On both these important points, therefore, the introduction of india-rubber would be of immense benefit, and it is believed that if it were clearly shown that the supply of material might be depended on, and the rate at which the wires could be covered would be equal to the demand, it would soon entirely supersede gutta-percha as a means of insulation. Experiments are also being carried out by another firm for the purpose of devising an insulator from a combination of india-rubber and shellac. These tests, however, are not sufficiently advanced to be made public, though the results up to the present give promise of success. When such efforts are making on all sides, it seems improbable that the use of a faulty and expensive insulator like gutta-percha will be much longer continued.—*Times.*

NEW CHURCH OF ALL SAINTS, MARGARET STREET.

THIS magnificent structure, the completion of which was, for want of funds, delayed for several years, has at last been finished, and was consecrated and opened on Saturday the 28th inst.

The site is a square of about 110 feet, occupied by the church and two houses; the church and houses surround on three sides a court yard which is open on the fourth side to the street. The two blocks of houses are connected by a low brick and stone screen with an effective archway in centre. The wall is surmounted by an arcade of open ironwork. The houses and screen form the entire elevation to the line of street. The church, situated at the back of these houses, occupies the whole length and remaining width of the ground behind them, from east to west, and parallel with the street. The church consists of nave and chancel, with aisles (north and south) to both nave and chancel, and of tower and vestry. The tower is at the west end of the south aisle and is embedded in its lower stage between the western house and the south aisle. The lower story serves as the baptistery. The whole of the church is carried on vaults of massive brickwork, upon the arches of which the concrete floor of the church is laid. There are no windows in the north wall of the church nor east end of chancel; owing to the confined nature of the site they could not be obtained, which has called forth peculiar treatment of the wall spaces. The architect has admirably turned the opportunity to account, and produced an effect most pleasing and novel.

The materials of the walls of the buildings generally are of red and black bricks and stone; internally, red and black bricks of a superior kind (made by Minton, of Stoke, Staffordshire) are freely used; Caen stone, marbles, and alabaster, in bands and mosaic, granite and other select stones, are used constructionally. The stonework internally is to a great extent decorated with inlaid patterns in dark cements. The marbles are chiefly of English production; the alabaster is from Derbyshire. The nave arches are of Caen stone, boldly moulded, supported by polished Peterhead granite clustered columns standing on black marble plinths. The capitals are of alabaster, carved in a masterly style, and of excellent design. A fine well moulded equilateral arch of alabaster, springing from a detached marble column on each side, divides the nave and chancel. The chancel is in its length divided into two bays, and is vaulted with chalk and alabaster; its western bays are each occupied by a traceried arch, opening into the chancel aisles. The heads of the arches contain tracery supported by circular columns of Cornish Serpentine with carved caps of statuary marble. The lower portion of the opening is filled up with an elegant brass and iron screen and gates. The eastern bays together with the east wall are arcaded in three heights; the whole arcading and wall space, sculptured cornices, and ribs of vaulting being entirely of alabaster, interspersed with Caen stone inlaid. The upper portion of north and south walls is occupied by tracery windows, filling up the triangular space formed by vaulting. The vaulting is enriched with inlays, gilding, and characteristic devices in colour. The arcade of east wall contains frescoes, by Dyce, representing in its two middle compartments, the Virgin and Infant Saviour, and the Crucifixion; six niches on each side contain the Apostles; surmounting them, and occupying the triangular upper space of wall, is a representation of Our Lord enthroned, surrounded by saints and emblamatic figures. All the figures are well designed and beautifully painted. The arcading of side walls is filled in with diapering in gold and colour. The nave and aisle roofs are of timber framing, with coloured enrichment. The rafters are all exposed, and ceiled between. The principals, purlins, and wall plates of nave roof are double, and are connected by rows of quatrefoils. The nave has a well proportioned arcaded clerestory, every fourth space being a blank to be filled with frescoes. Each of the other divisions of the arcade contains a two-light tracery window, from which the light for the interior is principally derived. The north wall of aisle is formed into panels by bands of incised stone, and will eventually be enriched with frescoes. The floor of the nave and aisles is laid with Minton's plain red and black tiles arranged in patterns, and divided longitudinally and diagonally by narrow stone bands; encaustic tiles are introduced at the junctions of the tile bands. The floor of chancel and beneath the tower is laid with various marbles intermixed with encaustic tiles.

A low screen separates the chancel from nave: the body of it is of alabaster, arcaded, panelled, and richly carved; the base, coping, and shafts are of various marbles. Brass gates of good design occupy the centre of the screen. The pulpit and font are of sculptured marbles of various tints. The metal-work in the church consists of brass gates in the chancel screen, and the side screens and gates dividing the chancel from its aisles. These screens are surmounted by rows of gas burners. The oak pyramidal cover of the font is also largely decorated with metal-work, and a brass lectern stands in the middle of the chancel. In the nave brass gas brackets of simple design are attached to the aisle-side of the columns. The metal-work was executed by Potter, from designs by the architect. The church is heated by hot water. The organ (constructed by Hill) is divided into two parts, and stands in the two chancel aisles; the two parts being connected by trackers beneath in the vaults.

The clerestory windows of nave and chancel are fitted with elegant bright-toned stained glass, designed by the architect. The west and south windows contain most unsuitable stained glass by Mr. Gerente, who, we believe, was commissioned by Mr. Hope. The chancel stalls are of oak and walnut, elaborately carved. The altar is of moulded and carved wood, and is surmounted by an alabaster super-altar, enriched with quatrefoils. An elegant metal cross is fixed immediately above it on the east wall.

Digitized by Google

The floor-space of the church is perfectly clear; chairs only will be used by the congregation. The mouldings and proportions of the work generally are bold and large, so as to give to the building an appearance of size which its actual dimensions would fail to impart.

The site was purchased by Mr. Beresford Hope, M.P. Mr. Henry Tritton, of Portland-place, we understand, provided the largest proportion of the building funds. Other subscriptions to it, we believe, have been comparatively small.

This building must not be compared with some of similar character which of late years have been erected by architects who have followed in the path struck out by Mr. Butterfield; for when this building was founded it stood alone as an example of revived principles of Gothic art adapted to modern requirements. It was intended to be truly a town church, built of materials of every-day use, produced in our own locality and country, and exhibiting the advantage of the truthful system of constructive decoration. The style of architecture adopted by Mr. Butterfield is the Early Decorated, in detail partaking of that exhibited by the ancient examples of France and Italy, but treated with considerable freedom and originality. It is but just that the author of this building should be placed in his true position as the pioneer and founder of the new school of Gothic art. Through the unfortunate stoppage of the works for a long period, other structures founded on the same principles were erected in the meantime, but from the similarity of treatment and peculiarities of detail which they possess, we must say that the authors are greatly indebted to the architect of All Saints' Church for their first principles.

ASSOCIATIONS FOR THE PROMOTION OF ART.

By G. F. Mulvaney, R.H.A.*

The author, after stating that he did not intend discussing any of the various phases or principles of art, but rather to draw attention to the condition of art in Ireland,—how it may be promoted, and the latent genius of the country be developed, said—

"It must be admitted that the state of art in Ireland is far from creditable to the country. It cannot be asserted that this is attributable to any deficiency of natural genius, or to any want of industry and zeal on the part of artists themselves. It results mainly, if not solely, from the want of public encouragement,—of that demand which has in all ages and in all countries led to the fullest development of human ingenuity and skill. The most frequent argument raised in defence of such a state of art-abeyance is, that we have not wealth enough for its adequate encouragement. The argument is unfortunately not without weight as regards individual patronage; but given its fullest weight, it is an argument *à fortiori* in favour of the associative principle which does so much for art in more wealthy communities. Perhaps it would be more candid to admit that taste, as a diffused social element—rather than wealth—is wanting. To generate and cultivate this public taste must be the first aim of all who desire to promote art in Ireland, and it is the chief aim of all art associations. Education of artists and of the public by schools and exhibitions are the functions of some; while others seek by the purchase and dissemination of the works of living artists to reward merit and stimulate taste by facilitating the possession of good works of art.

I propose to draw your attention principally to these latter institutions, but I cannot in the interest of the associative principle, especially within these walls, omit to pay my tribute of grateful admiration to the parent association for the promotion of the fine and useful arts in these countries. The Royal Dublin Society, established for the advancement of husbandry and the useful arts, promptly recognised the value of the fine arts in connection with industry. The principle so asserted by the establishment of its schools more than a century past, is now the recognised principle of government schools of design. The Society's schools rapidly acquired an importance not perhaps at first designed. Under the auspices of this Society, those wonderful achievements of ancient art—those marvellous embodiments of perfect form in almost breathing marble, the sculptured gods of classic Greece—became known in this remote island, awoke the artist's spirit to a new sense of beauty, and led rapidly to a new development of power.

Artists as they multiplied naturally sought strength in association; but beyond their influence in education and their efforts to maintain public exhibitions, I do not regard societies of artists as, strictly speaking, associations for the encouragement of art. They are producers, not patrons: they seek to cultivate art,—they are valuable rallying centres of professional union and distinction. It is their duty and their aim to raise the standard of public taste; but they are themselves dependent for existence and success upon an appreciative public. When incorporated by charter or royal sanction on the continent they are subsidised by the state. In these countries they are mainly dependent on the revenue from annual exhibitions: when these are prosperous, as in London and Edinburgh, the royal academies prosper, and acquire influence and power of effecting public good. The Royal Academy of London is perhaps the wealthiest association of artists in the world. It enjoys a revenue of £6000 or £7000 per annum from its exhibitions: and after maintaining its schools and establishment, and devoting much of its funds to charitable support of distressed artists and their families, it has amassed a large fund. The Scottish Academy has from similar sources of success derived a large income, and has made a noble use of it, by accumulating a fund for charitable relief, and the acquisition of a valuable collection of pictures at a cost of upwards of £15,000, which is now deposited in the National Gallery of Scotland. The Royal Hibernian Academy is unhappily, as regards worldly prosperity, but too true a reflex of the want of encouragement of art in the country.

Other associations may be referred to, such as the British and the Royal Irish Institutions, designed to afford objects of study to the young artist, and to cultivate public taste by the exhibition from year to year of works by the ancient masters, the property of private individuals. The latter named institution had but a brief existence, but it has found after the lapse of years a successor in the Irish Institution, established in 1853, with the ultimate aim of the formation of a National Gallery. The building now in course of erection in Leinster Lawn, to which the Dargan Testimonial fund has been devoted, combined with parliamentary grants, is the best evidence of the work done by the Institution, and assures to Ireland its long-desired National Gallery.

From the period however when the Dublin Society established its schools—when Barry and Barrett first won distinction, and carried off their fifty-pound prizes—to the present, the history of art in Ireland, with some fluctuations, has been the same: upspringing genius—well-directed philanthropic efforts to facilitate education—honour and reward to the student—struggles, difficulties, and non-appreciation for the artist. Hence it arose that so many distinguished Irish artists have followed Barry and Barrett to swell the fame of the British school, while many whose natural gifts and educated powers were at least equal to those of the emigrants, have remained at home—forced too often to devote talents calculated for higher development, to the mere drudgery of art.

I am far from undervaluing what has been done for the promotion of art in Ireland by the education of artists, or the cultivation of public taste; on the contrary, I honour those who have persevered through all difficulties in the good cause, and I rejoice that we may regard our educational facilities as being nearly placed on an efficient basis. But what I wish particularly to enforce is, that in point of national economy all those energies are without their proper return, if we do not find means to secure prosperity to the artist as well as education to the student. The developed intellect, skill, and productive power of a country are, even in an economic point of view, amongst its acknowledged elements of wealth. I need not, therefore, dwell on the importance of developing a national school of art—of keeping our gifted men at home, instead of forcing them to bring their talents and wealth-producing powers elsewhere. It will be better to show how this public good can be achieved. Example is better than precept or argument, and fortunately an example is found in the progress of art in Scotland.

Twenty-five years ago, the state of art in Scotland was not dissimilar to its present state in Ireland. There was perhaps more private patronage of art, but the public interest in its progress or demand for its productions was small indeed. The Royal Association for the promotion of Fine Arts in Scotland was established, I believe, in 1834. It was the first effort to introduce into these countries the German system of *kunst-vereine*, or art-unions. It has been signally successful in its operations. In its first year the funds subscribed did not exceed £700 or £800; its

* Paper read before the Royal Dublin Society.

Digitized by Google

average income now is about £5000 per annum. Not only has this association evoked a Scottish school of art, to do which was its first aim by the purchase of resident Scottish artists' works, but it has expanded its operations to the purchase of works of art without reference to the country of their production.

Strong objections were raised to the system of art-unions at the period of their introduction. It was said that they were calculated to interfere with private purchase of works of art, which, as the result of discriminating taste, and the legitimate expression of demand, was morally and economically the true encouragement to art. This objection was strongly urged by artists themselves; but experience has shown that it was not valid, and art-unions so far from diminishing, have considerably stimulated and increased both private and state patronage. I cannot better illustrate the force of these early objections and the power of successful experience in dispelling illusions, than by a short quotation from a speech made by Mr. Harvey, a distinguished member of the Royal Scottish Academy, at a dinner given by the committee and members of the Edinburgh Association in 1846. Mr. Harvey said:—'When the Royal Association for the promotion of art in Scotland was formed, rather more than twenty years ago, I at that time felt it my duty to be one of its resolute opposers, thinking it likely that the purposes of art would be better served by such works as might be produced being purchased by private parties in the usual way, rather than by funds acquired by public subscription, and the subsequent disposal of the paintings by lot. My friend, Mr. Glassford Bell, who was the great promoter of the scheme at the time, kindly said he would meet my opposition by the purchase of my paintings, should I produce anything which the association might consider worthy of buying; and accordingly I had an offer made to me in the ordinary way for one of my works shortly after. This offer, to be consistent, I declined, and I have the painting in my possession still. Since that time, however, I have seen fit to alter my opinion on this subject. In fact, when I call to mind that in, I think, either the second or third year of the Academy's existence, the entire sum received for works of art sold during the period of the annual exhibition was, if my recollection serves me rightly, only thirty-five guineas—one painting having been bought by the present Lord Justice Clerk, then Dean of Faculty, for thirty guineas, and one by some person else for five—it was evident that in this state of things something required to be done one way or another.'

This candid admission on the part of Mr. Harvey speaks volumes for the cause of such associations as we are now considering. In fact, such was the success of the Edinburgh Association, and so much was the demand and love for art increased in Scotland, that in 1842 the Glasgow Art Union was established. The success of this latter institution, at least as to amount of funds, is unparalleled in the brief history of art-unions. Of course the annual amount varies; but in 1856 it exceeded £20,000; and in the last report of the council of the Scottish Academy it is stated —such was the competition between art-union committees and private purchasers—that, on the opening day of the exhibition of 1858, nearly £5000 were expended in purchases in the gallery. A happy contrast, certainly, to the season referred to by Mr. Harvey, when the total amount of purchases was 35 guineas.

When the Art Union of London was established in 1837, there was no lack of purchasers, as the numerous and prosperous art exhibitions of that metropolis testified. However, beyond the enjoyment which those exhibitions afforded, the luxury, the home enjoyment of art was confined to the wealthier classes. So little were the purposes of art-unions understood, or so coldly was their interference with private purchasers regarded, that in the first year of the London Art Union, the subscriptions only amounted to £489 6*s*. The great middle classes, however, soon recognised the importance of the institution, and the total subscription for 22 years amounted to £238,932. The beneficial results of so large an expenditure, in addition to the undiminished amount of private purchase, must be obvious to every one. Some object to it as an artificial stimulus calculated to produce a superabundant mediocrity. I cannot regard it in any such light; for mediocrity in art will only be tolerated by mediocre taste, and the constant diffusion of good works of art through means of art-unions—the increased stimulus to good local exhibitions throughout the country—the very excitement about art so caused, must lead to improved taste. The works of the first-rate artists are never in the market for art-union purchase; not because those societies do not occasionally give high prices, but because those artists are pre-engaged often for years by private individuals. Through all these means a public opinion has been created, recognising the social value of art, and the importance of its highest development, which has stimulated the state—ever slow to move until it feels the pressure from without—to expenditure in the patronage of the higher branches of painting and sculpture, as well as to a gradually expanding system of education in art by schools and public galleries. Nor must we overlook another important fact in connection with such associations: it is not the wealth of particular localities that is represented in the large annual incomes of the London, the Edinburgh, or Glasgow associations. They draw their resources from all countries, and especially from our vast and increasing colonies, while it must be observed that the benefits of the expenditure is mainly confined to England and Scotland. From Ireland alone these three art-unions in 1858 drew upwards of 1150 guineas. The committee of the Glasgow Art Union remark in their last report, as a reason for not being more exclusively purchasers of Scottish artists' works, 'that a comparatively small amount of their subscriptions are obtained in Scotland.' Surely for us these are suggestive facts.

I have drawn your attention in the first instance to these institutions in Scotland, on account of the priority of their establishment, and because there exists a greater analogy between the circumstances of this country and that, than between those of Ireland and England. I would also say that the analogy was illustrated forcibly by the brief experience we had in Ireland of a prosperous art union. A gleam of promise—our national sunburst—shed its influence on art and art institutions. The exhibitions of the Royal Hibernian Academy expanded in size, interest and merit, and a consequent rapid improvement took place in the exhibition receipts. The energies of resident artists were awakened, and their ambition aroused. It was, unfortunately, a brief success, but it was enough to convince any thinking man, that in the associative system of encouragement lay the best hope of developing the latent talent of this country. I think too much stress is laid upon the failure of our first Art Union. It would be far better to regard the very large amount of success it achieved, as showing what can be done by well-directed energy. There may have been errors in the system, or improvidence in the management, which left the institution unprepared for the fearful ordeal through which this country had suddenly to pass; but, taught by experience, a system more calculated for permanence can be devised, and there is nothing in the present position of Ireland or its prospects to forbid the hope of resuscitating art, and establishing a school worthy of the country and 'racy of the soil.'"

THE OPERA FLORAL ARCADE, COVENT GARDEN.

When completed this building will be among the handsomest markets of its kind in the world, and an important addition to the ornamental edifices in London. The Arcade is now in rapid course of construction in the form of a lofty glass and iron edifice of striking and elegant proportions.

The ground plan and shape of the building may be best described as resembling the letter L; the handsomest and principal entrance being by the side of the Italian Opera, at the end of the longer arm of the letter, while the other opens upon Covent-garden Market, by the side of the piazza, at the end of the shorter arm. Over the space formed by the junction of the two arcades, at right angles, will be a lofty dome,—the first time that ever anything of the kind has been attempted in glass and iron only. The extreme length of the Arcade, from the Bow-street entrance to the west wall, will be 228 feet; and the short arm, from Covent-garden to the theatre wall, 100 feet. The width of both parts of the building meeting at the dome is 75 feet, of which the lofty semicircular arched nave occupies 50 feet, with two side aisles between the main columns and the walls, each nearly 13 feet wide. The springing of the arches for the roof is 29 feet from the ground, and as to the top of the arch is 57 feet, the roof is almost a perfect semicircle. The dome, when completed, will likewise be almost a hemisphere, 50 feet in diameter and about 25 feet high, making the total height to the ornamental lantern which will surmount it a little over 90 feet.

The great fault of all our glass and iron structures has been their deficiency in anything like ornamental details. Artists appear to have had nothing to do with them. From this great fault the Floral Arcade has been redeemed by Mr. E. Barry, the architect.

Digitized by Google

The Bow-street entrance is handsome and simple. The doorways are deeply recessed, so as entirely to do away with the flat, boxy, hard appearance which the entrances to such buildings have hitherto possessed. The raised iron arches which give admission to the interior also aid this effect considerably.

The radii of the arched roof seen on the outside are ornamented, and seem to spread out like an elaborate fan; and the curve of the roof over the entrance is surmounted with a kind of corona of elaborate cast-iron work. Glass and iron buildings are of course light in their construction, and this peculiarity, with the ornamental features mentioned, is particularly noticeable in the Floral Arcade. The iron columns supporting the nave roof are graceful looking, and instead of being, as is usually the case, mere iron cylinders, rough and unadorned as lamp-posts, they are all cast of an exceedingly handsome pattern, with rich capitals, which are perforated in order to ventilate the basement story beneath the market, with which the columns communicate. All round the interior at the springing of the arches is an elaborate cast-iron moulding of bold and rich design, which is hereafter to be gilt, when its effect will be exceedingly beautiful. The aisles are nearly 13 feet wide and about 30 high, the theatre wall forming the side of the north aisle, and the wall of the Arcade that of the south. As the theatre wall is pierced with recessed windows, the corresponding wall on the south side will be of the same kind. The arches which carry the roof of the nave are trellised, and apparently of the very lightest possible construction. Yet, light as they are in appearance, they are immensely strong in fact, and have all been tested with a strain far above anything that can ever come upon them, as they have nothing but themselves to support. Between the arched ribs transverse bars of "deck" iron, T-shaped, at intervals of about 6 feet apart, stretch along the whole length of each arcade, and are riveted to the arched principals in such a manner as to give to the whole roof the rigidity of one piece. The dome will be composed of twenty-two ribs, braced round with wrought-iron supports. The ribs form a quarter of a circle, all resting upon an iron collar in the centre, which will carry the lantern. The Covent-garden entrance continues the public way of the Piazza through its front by a roofed glass and iron gallery 50 feet long by 25 broad. The basement under the floor of the Arcade forms one of the most extensive cellars excavated anywhere out of the docks. It has the same immense area as the building above it, and is no less than 16 feet high; 10-inch cast-iron columns, forty-eight in number, carry the floor of the Arcade upon powerful wrought-iron girders equal to fifty times the weight that can ever come upon them. The floor of the Arcade is fireproof, formed of tiled arches between the girders, and over these an ordinary planking floor is laid for warmth and convenience. When the Arcade is complete it will be decorated in white and gold, a style which will admirably suit its light and elegant details. Through all parts of the structure pass hot-water pipes for keeping up the temperature during the winter, and gas is also laid on, so that the interior can be lighted up for night fêtes in an instant. This arcade is intended simply as a flower-market, to bring together in one building especially adapted for the purpose the immense trade which is now scattered all over the suburbs of London, in the hothouses and grounds of the great florists and nurserymen.

PRINCESS'S THEATRE.

THE splendid series of Shakespearean "revivals" which have been in course of production at this theatre for several years, and which have constituted so marked an epoch in theatrical art, is now about to be terminated, owing to the retirement of the manager from the scene of his arduous exertions. As a closing reproduction, well fitted to display the peculiar talents of Mr. C. Kean, and the resources of his establishment, the play of *Henry V.* has been judiciously selected. The interest chiefly centres in the monarch himself, into whose mouth our great bard has put some of the most stirring speeches he ever penned; the rest of the play is unequal, depending on the various accessories, and the abilities of the different impersonators; nevertheless it has always held a high place as a composition, and been a favourite with most of our good actors.

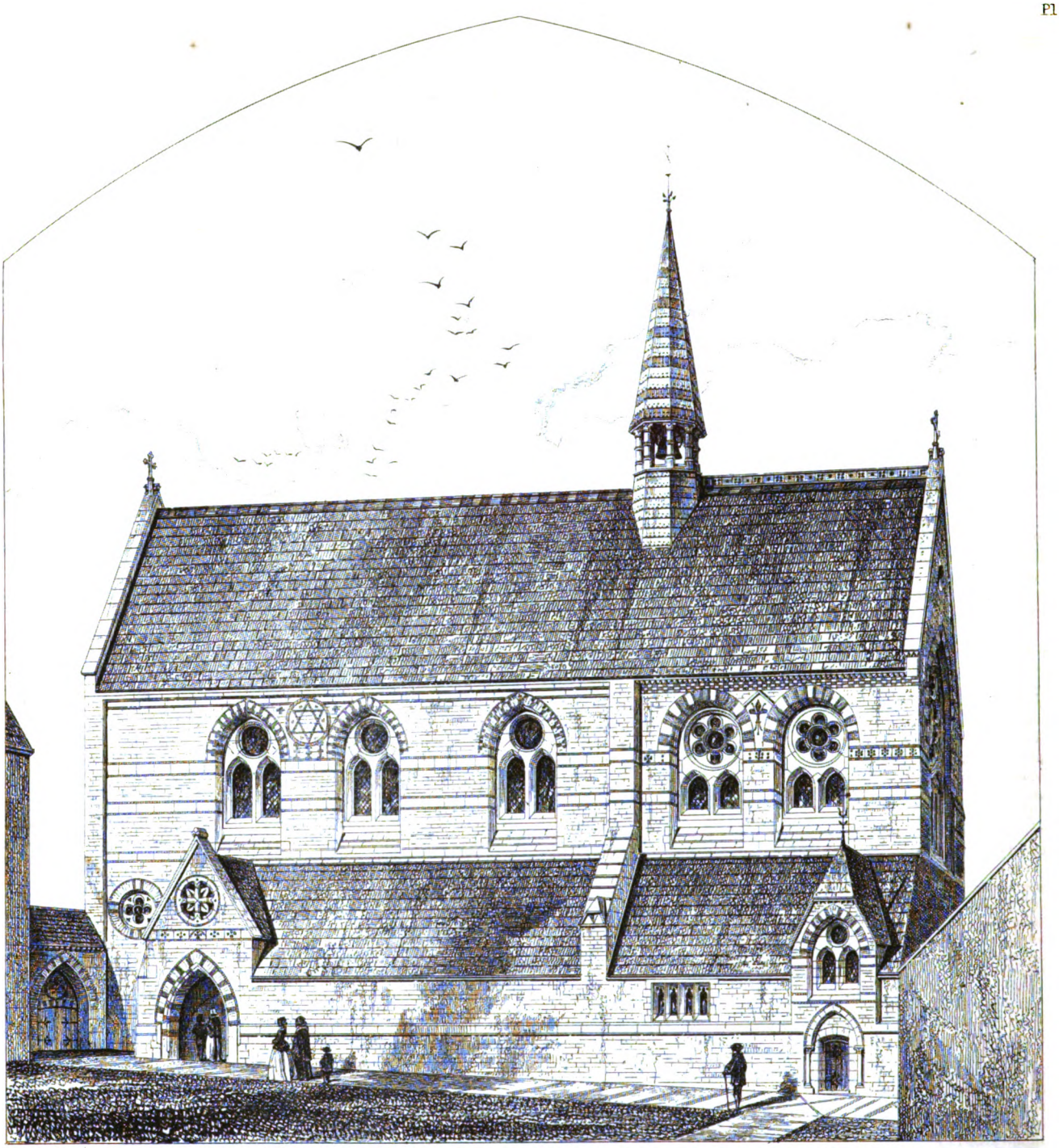
It will be unnecessary to observe that in the production of this play Mr. Kean in no way falls short of his previous successes, and far outshines all his predecessors in the *mise en scène*—a department of which he is so thoroughly a master; while Mrs. Kean, by a happy idea, exchanges the traditional figure of Time—under the semblance of an aged man, who had hitherto represented the "Chorus"—for that of Clio, the muse of History. This Chorus, or Clio, at the commencement of each act, in a kind of descriptive poetry, connects and explains the action as it proceeds, but Shakespeare has not in this instance assigned, as in *Pericles* and the *Winter's Tale*, a distinctive individuality to the character. In the "revival" of the latter play we took occasion to remark at some length on its special features; the present occasion does not call for such analytical criticism; Henry V. at the Princess's is rather to be seen than described: it is a splendid pageant, a complete study of costume and decorations, of which the variety and splendour can scarcely be imagined; and there is the more satisfaction in their contemplation since we are assured that they are, as nearly as can be ascertained, in strict conformity with the usages of the period. Bearing in mind this adherence to consistency observable throughout, we can only account for the declamations of the "Chorus" being made from a *classic* peristyle of the Ionic order, because in the present acceptation it is represented by a classic muse.

Some of the scenes are well deserving of notice. One of these shows "The painted chamber at Westminster" (to which frequent reference is made in history as the room in which Henry V. held his councils), and where the frescoes on the walls, and the superb throne powdered with the letter S, form conspicuous objects.—"A scene in Eastcheap" affords an opportunity for some characteristic groupings of picturesque old timber houses. "The council chamber in Southampton Castle," a venerable Norman interior, with rich tapestry round the walls. "The room in the French king's palace," in act ii., though showy, is not architecturally so good, but the landscape scenes of a "View in Picardy," and the "French camp," are triumphs of artistic skill. A great aim at effect has been successfully achieved in the realisation of the conflicting scenes at the seige of Harfleur, where the king's impassioned address tells with wondrous power on his dispirited army. But the *piece de resistance* is the "Historical Episode" introduced between the fourth and fifth act, and which is supposed to exhibit the reception of King Henry, on returning to his capital after the French expedition. It would be impossible to include the manifold incidents of the royal progress in one scene; neither could all the sites on which they actually took place be successively exhibited. The most prominent are, therefore, selected, and thrown into one locality—the approach to Old London-bridge. It will be recollected that, in the revival of Richard II. a similar interpolation was ventured on, and with so much success as to warrant this second attempt. In the last act there is a charming scene—"France in the neighbourhood of Troyes;" also a carefully rendered "Interior of the cathedral" at the same place. The high metal screen and grille work, in particular, are very accurately given.

Burford's Panorama Galleries, Leicester-square.—In China, India, and Switzerland are laid the scenes of the three panoramas now on view at this favourite place of resort. The former is the latest addition, showing "Canton after its bombardment." It has been painted, we understand, from photographs taken by the Royal Engineers; but if the visitor enter with grandiose expectations as to the probable beauty of one of the chief cities of the celestial empire they will assuredly be dispelled. There is positively nothing attractive nor even pleasing in the look of the buildings, nor is the surrounding landscape particularly enchanting. The dwellings are mean in appearance; they are also for the most part small, detached, and of the simplest and most monotonous character, while none of the streets exceed about 16 feet in width,—if we are credibly informed. Lucknow presents a totally different scene. Here the influence of civilisation and luxury are apparent: the buildings are numerous, large, and handsome; the oft-repeated dome, richly gilded, glitters in the sky; the parapet and balustrade are intermingled with Eastern features in a picturesque and fanciful manner. The roofs of the houses are uniformly flat, and are covered with a kind of cement. The church, a would-be Gothic edifice, has low pitched gables, which are thorough shams, the real roof being, like the houses, flat. Two bridges span the river, and the abundantly luxuriant foliage forms a refreshing feature in a landscape which has well been termed "the garden of India." The "Righi Culm" is well known to travellers as one of the special landmarks of Switzerland.

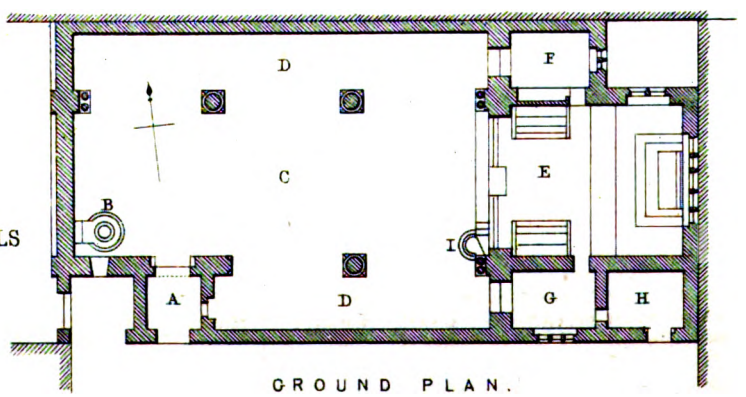
Digitized by Google

Digitized by Google



CHURCH OF

ST MICHAEL AND ALL ANGELS



GROUND PLAN.

BRIGHTON.

G. F. BODLEY, ARCHT

Digitized by Google

J.R.Jobbins.

NEW CHURCH OF ST. MICHAEL AND ALL ANGELS, BRIGHTON.

(With an Engraving.)

THIS church, of which we give an exterior view from the south-east, is about to be built at Brighton. The material employed will be brick for the walls both internally and externally. The arches, windows, doorways, &c. will be of Caen or Bath stone. The floor will be a paved one throughout. Moveable seats and chairs will be provided in the nave, and stalls fixed in the chancel. The principal dimensions will be—nave 23 ft. 6 in. wide and 66 feet long; aisles 9 feet wide; chancel 23 ft. 6 in. by 31 ft. 6 in. The height to ridge will be about 65 feet. The cost will be about £4000 for the fabric, and some further decorations will be added. The architect is Mr. G. F. Bodley, of Wimpole-street, London.

References to Ground Plan.

A. Porch.
B. Font.
C. Nave.
D. D. Aisles
E. Chancel.
F. Chancel aisle.
G. Sacristy.
H. Vestry.
I. Pulpit.

THE INSTITUTE OF BRITISH ARCHITECTS.

THE report just printed of the proceedings of the Institute during the past session is, on the whole, of a congratulatory character. Allusion is naturally made to their continued occupancy of the rooms in Grosvenor-street instead of having removed to their new premises in Conduit-street; and this is explained by the protracted difficulties which the Architectural Union met with even after the essential preliminaries had been gone through, in appropriating space, and effecting the alterations required by the several Architectural Societies which had to be located under the same roof. The accession of eight Fellows and ten Associates to the previous list of Members is notified,—the Institute now consisting of 154 Fellows, 139 Associates, 13 Honorary Fellows, 17 Honorary Members, 80 Honorary and Corresponding Members, and 13 Contributing Visitors. The losses to the Institute, occasioned by death, are next recorded, amounting in number to six.

To the subject of the Architectural Union Company reference is made at some length in the body of the report, and we transfer the remarks in full.

"The munificent example set by our noble President in presenting twenty shares in the Architectural Union Company to the Institute, has been followed by our respected Fellow, Mr. Tite, M.P., who has given ten shares, and by Mr. St. Aubyn, Fellow, who has just presented five shares, in the same company. Should these donations be increased by other friends and members, the prospect of the Institute becoming, in a great measure, its own landlord would be far from Utopian. To those who may not think fit to present shares, it may perhaps be permitted to suggest the establishment of an auxiliary fund, on the present occasion of removing to new apartments, in order to meet the heavy demands on the stock of the Institute, by which the annual income will be lessened, while an increase will take place in the rent. (Since this Report was read, Mr. T. L. Donaldson, Fellow, has presented the sum of 25*l.* to the 'Removal,' and the like sum to the 'Travelling' Fund.) The rooms in Conduit-street are fully described in last year's Report: but it may be again mentioned, that on four evenings during the session the Institute will have the right of using the whole suite of spacious galleries at the back of the main building for conversazioni and similar purposes. The council believe that by judicious arrangements, and the zealous co-operation of the body at large, the institution of these conversazioni may be made an important and not unprofitable feature in the sessional proceedings. The organisation of the arrangements, in which they trust they may be aided by an efficient committee, selected mainly from amongst the younger members of the Institute, will doubtless form one of the most interesting duties of the council during the ensuing session.

"The Architectural Exhibition and the Architectural Association have already taken possession of the galleries; and respectively inaugurated the event by very successful opening meetings.

"To the Architectural Exhibition Committee, its zealous Secretaries, and Treasurer, too much praise cannot be given for the spirited manner in which, in face of no ordinary difficulties, they originated the Architectural Union Company, which has carried to a most satisfactory conclusion the intention of providing in spacious, well lighted and well arranged galleries that amount of accommodation for the architectural world in London, which the Royal Academy denied within its walls; and afforded moreover constant means for the display of objects of utility as well as of artistic merit connected with building operations, never attempted before the establishment of the Architectural Exhibition.

"The council feel that they are expressing the feelings of the Institute, when they record their best wishes for the permanent success of the Architectural Union Company, which has united under one roof 'The Architectural Societies of London.'"

In addition to the subjects for papers and discussions brought before the ordinary general meetings, three of great interest have engaged the attention of meetings specially called to consider them. These are as follows, and it will be at once seen that their due investigation is of weighty importance as regards the prospective condition of the profession at large.

"The extension of the elective franchise as well to members of this Institute as to the members of other professions hitherto specially designated 'learned' (as proposed by Her Majesty's government), was considered an act of simple justice, which found expression in a petition agreed to unanimously at one of the meetings; which, having been duly authenticated by the corporate seal, was presented to the House of Commons by our Fellow, Mr. Tite, M.P. for Bath.

"The same unanimity prevailed respecting the necessity for supporting the prayer of a petition on the subject of artistic copyright, before a committee of the House of Lords about to consider the subject; and a committee of the Institute, consisting of Messrs. Donaldson, Godwin, Hayward, Kerr, Norton, and Papworth, has been named by the council (which had been duly empowered by the meeting), to press the purport of that petition before the Lords. Mr. Cockerell, Fellow, R.A., the council regret, is prevented by ill health from affording his valuable assistance as a member of the committee.

"A discussion in the House of Lords respecting the removal of the Royal Academy from Trafalgar-square, in order to devote the entire present building to the national collection, having called attention to the probable readjustment, if not of the constitution, at least of the working system, of the Royal Academy, a memorial to embody the views of the Institute on the subject was submitted to a special general meeting; and further considered at a second. At a third meeting a modified memorial to the council of the Royal Academy was agreed to in the following terms:—

"'The Institute of British Architects conceive it to be their duty at the present juncture, to offer their congratulations to the Royal Academy of Arts upon the probability of its speedily obtaining a site eligible for the erection of buildings more suitable for the requirements of the annual exhibition, library, art collections, schools, lectures, &c., than the premises it has hitherto occupied. By its steady maintenance of these and other educational institutions, it is undeniable that the Royal Academy has conferred inestimable benefits upon the fine arts of this country, and none can be more ready to subscribe to this fact than the Institute of British Architects. So highly indeed do they esteem the advantages which have been hitherto derived by the profession which they, to a certain extent, represent, that they cannot refrain from urging upon the Royal Academy in any re-adjustment of its present arrangements, the expediency, and indeed duty, of yet further extending and developing those advantages.

"'The Royal Institute of British Architects conceive it both more respectful to the Royal Academy, and less likely to prove prejudicial to its interests, to at once state openly their impression of the mode in which this can best be carried out, than it would be to remain silent, and yet not altogether satisfied with the prospect of the bare maintenance for the future of that which may have been sufficient in the past.

"'The following are the general arrangements which, if it were possible, the Royal Institute of British Architects would desire to see carried into effect by the Royal Academy:—

"'1st. A larger proportion of Architectural Royal Academicians and Associates to be appointed.

"'2nd. Powers of independent action to be given to the Architectural Members, upon matters connected with Architecture.

"'3rd. The provision of means of instruction in their art to be provided for Architectural Students, equivalent to those afforded by the Royal Academy to Students in any other branch of the Fine Arts.

"'4th. A more systematic scheme of general instruction in all branches of the Fine Arts to be brought into operation, and more efficient tests by examination, or otherwise, of knowledge and proficiency in practice.

"'The first point (the increase of architectural academicians and associates) the Royal Institute of British Architects conceive essentially due to the great extension which has of late years taken place in the study and practice of architecture, and its subservient arts of design in this country.

"'The second, independent action, is indispensable to prevent the architectural element being rendered powerless through its remaining on all occasions a small minority.

"'The third, architectural education, it is conceived, it would be incompatible with the comprehensive objects for which the Royal Academy was originally instituted, to refuse. And the fourth, a general elevation of academic art-teaching, is unquestionably demanded by the public for students in architecture, if not in all the other departments of the fine arts.

Digitized by Google

"'As considerable excitement is felt throughout the profession upon the subject of the present communication, it is proposed to give publicity both to it, and to whatever reply the Royal Academy may make to it.'

"The Institute must now await the result of this appeal to the good sense of the Royal Academy. The council must however express the sincere hope, that whatever course may be finally adopted by that body, it may be such as to confer material benefit on each and all of the equally important subdivisions of the fine arts.

"The council, in common it is believed with all well-wishers to the maintenance in an honourable position of the architectural profession, have felt and continue to feel profound anxiety with respect to the establishment of a more systematic course of education for the student in architecture than has hitherto prevailed. Looking naturally to the Royal Academy as the legitimate source of initiation, the council will seriously discuss and endeavour to originate some movement in this matter, in the event of the Royal Academy failing to provide a more active curriculum than it has hithertofore considered necessary. The subject is, however, obviously one of such extent and gravity, that any useful action can be only set on foot by the very hearty concurrence, not of the council or of the Institute alone, but of the whole body of architects practising in the United Kingdom."

Referring to the subject of architectural competitions, it is mentioned that the attention of the Council has been recently invited by Mr. Edward Barry to another phase which the matter is now occasionally assuming, viz., the practice of requiring competitors to undertake the task of deciding upon the designs submitted. The remarks of Mr. Barry were deemed by the council so pertinent, that they have felt that they could not do better than record them, as embodying a reasonable and logical statement of the case; being impressed with the necessity which exists that competitions (if competitions cannot be avoided) should be conducted in the best possible manner.

"In the absence of any expressed opinion on the part of the profession, it is not unlikely that this mode of determining competitions may become popular with those who conduct such matters, as at first sight it undoubtedly presents an impartial and captivating appearance. Isolated competitors can never hope to oppose with success regulations determined without their knowledge, nor can resistance be made effectually as each case arises. It is obvious that judgment of any kind which seeks to command respect, should proceed from a person or tribunal of *known* fitness for the task, and it may be doubted whether in a competition conducted anonymously, and in which the majority is likely to be composed of those who have their reputation to make, this essential condition can be adequately secured. Another point requiring much consideration is the difficulty of preventing collusion, fictitious voting, and other irregular acts, when strong personal feelings and private interests come into play, and when the corrective influence of public opinion can hardly be brought to bear. Instances may readily be imagined, when one competitor, who has sent in more than one design, may concentrate his several votes on one of the number; or when he might obtain votes from another competitor, who might feel his own chance hopeless, and who might be actuated by personal friendship or less creditable motives. There are besides many difficulties, such as the compulsory revelation of the names of the competitors who having been unsuccessful may not be desirous of publishing the fact, and also the equality of the authority of the votes, though the relative qualifications of the voters have not been in any way ascertained. This however is not the opportunity for entering at length upon the consideration of these difficulties, which may or may not be inherent to the nature of the case."

Besides these several topics, allusion is made to the "Nine hours movement" among the men employed in the various branches of trade connected with building; and also to the urgent call now existing for improving the main lines of intercourse through this rapidly-increasing metropolis. The attention of the legislature would seem to be now alive to the subject; and the system of railway communication is apparently on the eve of further development by the completion of the circuit round London, and by its continuation into the western centre at Charing Cross.

The retirement of Mr. Digby Wyatt from the office of joint Honorary Secretary is announced;—that gentleman having accepted the duty three years ago on the understanding that he should be at liberty to relinquish it at the expiration of a twelvemonth. His connection however with the new position of the Institute induced him to continue his services till the present time, when he has the satisfaction of seeing future arrangements so far complete as to leave comparatively little on that score to be accomplished by his successor, Mr. T. Hayter Lewis.

The Council also notify with sentiments of deep regret that their late Honorary Secretary for Foreign Correspondence, Mr. T. L. Donaldson, who had long held that position with much efficiency, has communicated his wish to be released from office, a notification which they have had, of course, "to accept and deplore."

"For twenty years that office has been held by Mr. Donaldson with honour to himself and benefit to the profession both at home and abroad, and for several years previously to his acceptance of that office the even more onerous duties of joint honorary secretary had been no less sedulously and creditably performed by the same gentleman. No resolution, however powerfully it may be worded, can be adequate to convey a just impression of the council's estimation of such services given for so long a period—so freely, zealously, and with an enlightened jealousy for the conservation at all times and under all circumstances of the best interests of the art and its professors. They desire, nevertheless, to place upon their minutes this inadequate record of the feelings of gratitude which they will ever entertain towards Mr. Donaldson for his untiring labours to uphold this Institution, and all that is most worthy of admiration in the cultivation and practice of the fine arts."

At the request of the Council, Mr. F. C. Penrose has allowed himself to be put in nomination as Mr. Donaldson's successor. The list of office-bearers for the new session includes the names of Earl de Grey as President; Messrs. Ashton, R. C. Hussey, and Godwin as Vice-Presidents, and C. C. Nelson and T. H. Lewis as Honorary Secretaries.

THE JEWS' NEW HOSPITAL, MILE END.

In the early part of this year designs were advertised for, with offers of premiums to the three which should be ultimately most approved, with a view to the erection of a new hospital for this institution. The instructions laid down were very clear and explicit, and the names of the intended adjudicators, Messrs. D. Mocatta and M. Digby Wyatt, were also published. The competition drawings were lately sent in, and the adjudication being made, they have been on view to the public during the week just closed, at Sussex Hall, Leadenhall-street, in compliance with a suggestion made in the judges' report, to which we shall again refer.

There were thirty-three designs forwarded in answer to the advertisements, and the report expresses, in more laudatory terms than perhaps we should have been disposed to do, an opinion as to the "high average of excellence" that presented itself. The style which seems most in favour among their authors appears to be the Italian, more or less freely used; some few are decidedly Gothic, introducing foreign elements, and two or three may be described as Romanesque, for want of a better term. The three premiums have been, oddly enough, distributed among these three classes; the first (of £100) to Messrs. Tillott and Chamberlain; the second (of £50) to Mr. C. H. Cooke; and the third (of £30) to Mr. J. P. Jones, their respective mottoes being "Experientia," "Faith," and "Alpha." In arriving at the decision, which appears to have been done with great impartiality, the judges explain the course they followed, viz., by making their examination individually at first, and then comparing notes, reducing the number for a final consideration to eight, which they considered "apparently eligible for reward." There were however found drawbacks in some of these which led to their being set aside, such as extravagance, want of supervision, inconvenient arrangement, or defective construction or design. Ultimately the number was brought down to *six*, which were submitted to the surveyor to the charity, Mr. S. B. Wilson, for the purpose of ascertaining, by means of "quantities," the probable comparative cost which each of these would involve if carried out. The completeness of the drawings and specification furnished by "Experientia" enabled him as regards that design to do this with tolerable certainty, and furnished data for the estimation of the others, and Mr. Wilson gave in his figures to the referees, who requested him to re-investigate the matter, subject to certain modifications which would place the authors of the designs on a more equal footing. The result, as shown in Mr. Wilson's second report, dated June 7th, exhibits the relative cost of the three designs which seemed most deserving as—

"Experientia"	£10,813
"Faith"	11,124
"Alpha"	11,478

Taking into account the average variation of amounts of tenders in competition for similar buildings, the adjudicators "see no reason to positively reject any of the designs on the score of excessive expense, as we believe that, according to either of these

Digitized by Google

designs, a building might be executed which should fulfil all the conditions we had made imperative upon the competitors."

With respect to the special merits of these three designs, and of the remaining three of the six eligible sets to which they reduced the entire collection, they remark:—

"That the design 'Experientia' will be found to afford the whole of the prescribed accomodation in a remarkably compact, and consequently economical form; the arrangement for air, light, subdivision, freedom of communication, and convenience of economical household service, leave nothing to be desired; while in the important point of so limiting the frontage as to admit a perfect circulation of air around the whole building it stands alone. The external appearance of this building, should it be carried into execution, will prove satisfactory, avoiding alike any very marked assumption of peculiar style and any extravagance of effect. It would be handsome and appropriate, and would be rather improved than injured by the proposed diminution in height. The proportions of the first-floor windows and the roofs over the angle pavilions might be improved by judicious study and retrenchment.

"The design marked 'Faith' is the work of a good practical architect, being both well planned and gracefully designed. It wants, however, the compactness of 'Experientia's' arrangement, and could not be so conveniently or economically administered. The boys' school-room and the large dormitories would be scarcely lofty enough for their area on plan. It is however, upon the whole, a highly meritorious design.

"The design marked 'Alpha' is not quite equal to the last named, being defective in some of its lavatory arrangements and servants' bed-rooms. In picturseque grouping of the various buildings, as seen from the grounds of the establishment, it is superior to any other design of the whole series. The front is also well drawn, but is not quite consistently carried out in its leading features. With regard to the remaiuing three designs which deserve commendation, although not among the premiated, we desire to record, in the first place, our admiration of the picturesque arrangement adopted by the author of the design marked 'Celsus,' and of the merit of his plan, with one feature of which —the bringing forward to the front in detached buildings of the aged persons' house and infirmary—we were much pleased. We could not, however, bring ourselves to believe that this picturesque grouping and effect could be attained for the amount to which your contemplated outlay has been limited.

"With respect to the designs marked 'Veritas, No. 2,' and 'Economy,' we would remark that in both a compact and utilitarian distribution on plan is combined with sedulous endeavour to restrain expenditure within prudent limits."

The author of the design marked "Celsus" proves to be Mr. G. Morgan, of Danes'-inn; and of that marked "Veritas," Mr. H. H. Collins, of Torrington-square. There does not appear any name answering to that entitled "Economy."

It may be added that the building is for the reception of 100 boys and 40 girls, and is to include, with dormitories and school rooms, a dining-room for 150 persons, a synagogue 37 by 24 feet, and a detached building for six aged males and six aged females.

WATERGLASS, AND ITS PROPERTIES.

We took occasion in a previous number of our Journal (Sept. 1858) to describe at some length the properties of the chemical application for preserving materials known as "Waterglass;" we are now enabled to supply some additional facts, contributed by one of the earliest experimentalists on the subject, Dr. Johann Nep. Fuchs, in a paper which has been translated by desire of, and communicated to the Society of Arts by H.R.H. the Prince Consort, its president. The document touches upon a vaoiety of themes which, as they do not bear upon questions which it is not our province to lay before our readers, we need not further allude to, while their omission will greatly curtail the use that might be made of a really valuable contribution to science. (The whole will be found printed at length in a recent number of the Society's Journal.)

So far back as the year 1825 the learned author published a paper on "Waterglass," which at that time, however, did not meet with the attention which the subject well deserved. This was partly attributable to the non-success of certain experiments which were undertaken without the necessary previous acquaintance with the subject. Great were the expectations raised by the discovery. Failures, owing perhaps to faulty manipulation, frequently caused it to be abandoned before it had been put to a fair test.

The manufacture and the properties of the waterglass have been fully described in Kastner's Archiv., but Dr. Fuchs has thought it desirable to reproduce the more essential parts of that paper, since he is able to introduce many improvements, and to treat more amply of things which at that time were but cursorily indicated.

Various kinds of Waterglass, and their Manufacture.

"We have to distinguish four kinds of waterglass:—*a*. Potash waterglass. *b*. Soda waterglass. *c*. Double waterglass. *d*. Fixing waterglass.

"The name 'waterglass' is, in fact, a generic name employed when speaking of the above four varieties. I do not know whether a lithia waterglass might be obtained. Perhaps a good double waterglass of potash and lithia might be produced by replacing a part of the potash by lithia, for which purpose lepidolite could be conveniently employed. This double waterglass would no doubt be rather expensive; cases might, however, occur where expense would be a matter of secondary importance.

"I was for a long time of opinion that the ordinary waterglass, after being completely saturated with silica, forms the best and the most suitable for all purposes."

"(Freshly precipitated or gelatinous silica offers the best and most convenient means of ascertaining whether a sample of waterglass is completely saturated with silica, by introducing it in small portions into the boiling liquid, when a saturated solution will dissolve no more, whilst an incompletely saturated solution takes up more or less.)

"A serious inconvenience, however, showed itself in its application to stereochromy; in the last operation, that of fixing the colours, the pictures assumed a cloudy and dirty appearance in consequence of the rapid partial decomposition of the waterglass. This drawback caused much anxiety, and suggested the idea that in this case the waterglass ought not to be completely saturated with silica. A few experiments proved this opinion to be correct; and by adding a portion of soda liquor silicum, or soluble silicate of soda, to the ordinary waterglass completely saturated with silica, I obtained a waterglass which perfectly answered the purpose. I call this mixture *fixing waterglass*.

Properties of Waterglass, and its deportment with other Bodies.

"It is important to study thoroughly its action upon other bodies in order to prevent errors, or drawing erroneous conclusions from certain changes or phenomena.

"Solid or fused waterglass, if pure, has the appearance of ordinary glass, and dissolves gradually but completely in boiling water; in the cold, however, the solution proceeds so slowly, that one feels inclined to believe that it is entirely insoluble in cold water. It becomes entirely insoluble only when a much larger quantity of silica has been added and made to combine with it, or when a portion of potash has been withdrawn; frequently, also, when other bodies, viz., earths or oxides of the metals, &c., have been mixed with it, which form double or triple silicates, such as many mineral compounds and common glass itself is composed of; for I have always noticed that silicate combines more readily with two bases than with one.

"Acids—carbonic acid not even excepted—decompose the solution and separate silica in a gelatinous form. Solid waterglass is readily acted upon by dilute acids, and silica is separated in the form of a powder.

"Salts of the alkalies, especially the alkaline carbonates or chlorides, cause viscous precipitates from a concentrated solution, and the whole solution seems to coagulate. In dilute solutions, a precipitate appears only after some time. Sal-ammoniac acts most powerfully by producing, even in a very dilute solution of the waterglass, a flaky precipitate, ammonia being simultaneously evolved. On washing this precipitate with water acidulated with nitric acid, pure silica is left on the filter.

"The alkaline earths set free more or less potash on being brought into contact with a solution of waterglass, and combine with the rest of the potash to form double salts which are quite insoluble in water.

"Alumina combines likewise with it, and forms a product insoluble in water; it is therefore necessary that the quartz which is used in the manufacture of waterglass should not contain any alumina. The insoluble residue which is left behind when the fused mass is dissolved in water, is probably owing to the alumina which the glass has taken up from the glass-pot.

"If the waterglass is dissolved and exposed to the air in open vessels, it attracts carbonic acid and suffers decomposition, which causes it to coagulate sooner or later, and produces gradually a slimy deposit, which was found by Professor Buckner to contain potash.

"Heat accelerates this decomposition. If the liquid is evaporated and the dry mass made anhydrous by further heating, it swells considerably, and will then be almost entirely decomposed. Water no longer dissolves it, and acids produce strong effervescence. By calcination it is

Digitized by Google

brought back to its original state, and becomes again completely soluble in water.

"It is evident that constant boiling is required to obtain the soluble waterglass in a solid state by means of evaporation, in order to prevent the carbonic acid from penetrating the mass. The same precaution must be observed when fused waterglass has to be dissolved, and care must be taken always to add boiling water in order not to interrupt the ebullition, and thus to allow the access of carbonic acid.

"When solid or pulverised waterglass is exposed for some time to the action of the atmosphere, it undergoes the same change as during the evaporation. It effervesces strongly on addition of acids, and is only partly soluble in water, leaving a heavy desposit. On being strongly ignited, this residue becomes again soluble. If a drop is allowed to fall on the table or on the floor, it soon loses its transparency and becomes opaque, owing to a partial decomposition. The same takes place when it is poured from a bottle and a drop runs down outside the vessel; white streaks, which are difficult to efface, make their appearance. If the liquid glass is kept in a bottle which is only half-full and badly stoppered, a white deposit or ring is formed after a short time, which adheres so firmly that it cannot be removed entirely even by acids, and a more or less heavy deposit is found on the bottom of the vessel, owing to a partial decomposition of the waterglass—a fact which I did not become aware of for some time, on account of insufficient experiments and observations.

"When concentrated waterglass is brushed upon a solid substance, such as glass, marble, or thick paper, it soon dries up and forms a shining transparent coating, which, however, does not keep long, but becomes gradually dull, opaque, and sometimes fissile and cracked, and of a somewhat pulverulent appearance. This gradual change is caused by water, which the air-dried waterglass retains in rather considerable quantity (about 12 per cent.), and which it loses but slowly, whilst it contracts more and more and acquires considerable hardness.

"One of the most important properties of the waterglass, and one which renders it most suitable for practical purposes, is its binding and cementing power; it may be employed for imparting solidity and greater cohesion to loose masses, for joining separate parts of bodies or small particles to form a large whole, for filling up cracks or fissures, &c., and many more applications. Its action resembles that of glue; and it might, in fact, be called a mineral glue.

"Its effects are most apparent when it is applied upon solid porous bodies which absorb it, and when it is brought together with pulverulent dust or sand-like bodies, or with substances which can be crumpled up between the fingers, but which are converted into a stone-like mass, from which the waterglass can no longer be dissolved.

"The intensity of the effect produced depends upon the nature of the substances with which the waterglass is brought into contact; some possess a stronger affinity than others, and consequently are more powerfully cemented than others. There is, however, this essential difference, that a few, such as magnesia and oxide of zinc form with the waterglass a chemical compound, whilst others are only mechanically combined, owing to mere adhesive action. The former action, by which bodies are rendered hard and insoluble, will be readily understood, because an insoluble double silicate is formed by the combination with a second base. The latter is more difficult to explain, especially since the waterglass shows a slightly different deportment with different bodies, and it is therefore not at all immaterial which body is chosen in order to obtain an intimate solid mass which resists the action of the water. Thus, for instance, waterglass exhibits a much greater power of adhesion for powdered marble than for powdered quartz. It has been shown, moreover, that the carbonic acid of the air promotes the consolidation of the waterglass, because it is partially decomposed when exposed to the air; however, this is not sufficient to explain the striking change which frequently becomes perceptible after the lapse of a few days. Carbonic acid, no doubt, loosens the slight tie which exists between silica and the alkali; but then the former does not remain passive, passing, according to its peculiar nature, through various states of cohesion, becoming itself active, retiring, so to speak, entirely upon itself, and cohering so intimately with the particles of the body with which it is brought into contact, and for which it possesses a strong adhesion, that the whole mass becomes petrified. If, therefore, a body does not readily cement with waterglass, it will only be necessary to add a material which combines chemically with the latter, when the desired end is sure to be obtained.

"I call a mixture of pulverulent or sand-like bodies with waterglass which cements well, *waterglass cement*. It may be advantageously employed in various cases instead of the common chalk-cement, as will be shown hereafter.

"Waterglass imparts considerable hardness to porous bodies which absorb it, such as vessels of baked clay, plates, bricks, tiles, pottery-ware, &c.; as also to porous limestones, sandstones, and to timber.

"It has been stated that waterglass does not cement all solid bodies equally well, and it will be interesting to know which bodies are more or less inclined to combine with it. I will mention only those which are available for practical purposes, and state the experiments which were made to ascertain their deportment.

A.—Carbonate of Lime.—(Chalk, Calcareous Sand, Powdered Marble.)

"When chalk-powder is made into a paste with water and then well dried and saturated with waterglass, it forms a compact mass. According to Buchner, if a piece of chalk is plunged into a moderately concentrated solution of waterglass, and left for about two days in the solution, then taken out, dried, and again put into a somewhat more dilute solution, it is found to be entirely soaked with it, and acquires on drying such an even hardness that it is very little inferior to marble, and capable of a good polish. Water does not soften it, though it assumes a slight alkaline reaction; the chalk is also increased considerably in density. Baron Liebig and Professor Buchner have confirmed this remarkable deportment of waterglass by their own experiments. Chalk therefore forms an excellent ingredient in order to render waterglass cohesive and insoluble in water.

"Powdered marble exerts the same action upon waterglass as chalk, and forms a very compact mass with it, especially a very good cement. This cement, which may be prepared of more or less coarsely-powdered marble, may find useful application for many practical purposes, as well as the analogous mass of chalk and waterglass, since it adheres to wood as well as stone.

B.—Dolomite,

"A mineral consisting of carbonate of lime and carbonate of magnesia, which, according to experiments lately made, appears to surpass even limestone in its cementing power; and as it is considerably harder than limestone, a mixture of its powder with waterglass imparts a strong resisting power against external mechanical as well as chemical action. It may be classed with the best means of cementing the waterglass and to render it insoluble in water; and since it occurs frequently in nature, it may be obtained without incurring any great expense.

C.—Phosphate of Lime.—(Bone-ash.)

"Phosphate of lime also gives a very compact mass with waterglass, scarcely differing in consistency from that with carbonate of lime, and, as far as has been ascertained, without undergoing any chemical action or change of its constituents. Although it is not likely that phosphate of lime will be much employed, it is interesting to know its deportment with waterglass, because it is sometimes formed by the combination of phosphoric acid and lime and brought into contact with waterglass, as will be further illustrated hereafter.

D. Caustic Lime.—(Slaked Lime.)

"Waterglass sets rapidly when caustic lime is mixed with it, and dries slowly to a rather hard mass. A chemical combination takes place between the lime and waterglass, and potash is liberated, if a sufficient quantity of waterglass be present. It is evident that water has no action upon this product. It may serve advantageously as an admixture to other masses which do not cement so well; only little can be added, however, lest the solution sets and prevents the waterglass from penetrating.

E.—Lime acted upon by the Atmosphere—(Basic Carbonate of Lime)

"May conveniently be added to waterglass by rubbing the two substances together; it does not set rapidly, but dries up gradually to a solid mass, which is a chemical product consisting of silicate of potash and lime. Slaked lime forms a useful addition to other masses, since it will soon be converted into carbonate of lime by the action of the carbonic acid of the air; and walls coated with mortar may, after a short time, be impregnated with waterglass in order to cement them better.

F.—Pulverulent Quartz.

"Quartz may be powdered as finely as possible without exhibiting any strong adhesive power or inclination to form a cement with the waterglass. If it be made into a kind of cement, and placed upon a tile moistened with waterglass, it dries up to a solid mass after a few days, and resists rain, and becomes as hard as a stone on the surface. But if that surface is pierced and the inner part examined, it is found quite disintegrated and void of waterglass, the whole of which has been drawn to the surface. Repeated soaking in waterglass is necessary to render the mass homogeneous. A compact mass which leaves scarcely anything to wish for, is however obtained when a little dry-slaked lime is mixed with the powdered quartz, and then the mixture treated with waterglass.

"The same takes place when waterglass is added to mortar made with quartz-sand and slaked lime, after the mass has been well dried.

G.—Burned Clay, and Burned Porcelain Clay.

"These two bodies do not belong to those which bind well with waterglass. We observe the same action as with powdered quartz. The waterglass only combines superficially with them, and leaves underneath a porous powder, which will only bind if repeatedly moistened with waterglass.

"There exists a remarkable difference between vessels made of different kinds of clay, which become, as is usual, porous by burning, so that they absorb the waterglass readily. If, for instance, a burned plate of potter's clay which possesses no particular hardness, and can easily be broken to pieces, is saturated with moderately concentrated waterglass, and if the soaking is repeated after it has become dry, it is rendered so hard that it resists both chemical and mechanical action which is made to bear upon it.

H.—Zinc White (Oxide of Zinc) and Magnesia.

"These two bodies combine most energetically with the waterglass, and

Digitized by Google

hereby show the same close analogy which we notice in several others of their natural as well as artificial chemical compounds.

"If the mixture of oxide of zinc and the waterglass is brushed in a thin layer upon objects, it adheres firmly to them and gives a good coating, to which a colour may be added, if desired.

"This powerful action of the oxide of zinc makes it a very useful article to add to those substances which, by themselves, do not bind readily with waterglass. Even to those that do, a small admixture of the salt can be advantageous, and tends to increase the solidity, or, at all events, prevents the waterglass from making its way to the surface.

"*Gypsum.*—Hydrated Sulphate of Lime (CaO, SO^3+2HO).—When gypsum is ground together with waterglass it solidifies immediately, and on drying much sulphate of potash or sulphate of soda separates, according as potash waterglass or soda waterglass has been employed in the experiment. The mass is however scarcely more solid than the ordinary gypsum. No doubt a chemical action has taken place. It follows that objects made of gypsum cannot be impregnated with waterglass in order to render them more solid and capable of resisting the action of the atmosphere, because it does not penetrate into the pores. Gypsum must therefore be avoided in selecting admixtures for the waterglass; moreover, care must be taken to avoid such bodies as might form gypsum in the operation, or as might already contain gypsum.

"*Anhydrite*, or anhydrous sulphate of lime, and I think strongly ignited gypsum, promise a better result; but I am unable to speak definitively on this point, as the experiments have not yet been brought to a conclusion.

"The late sculptor Professor Maier told me, that he was enabled to employ a faulty stone in a few days as if it had contained no fissure, by dropping a few drops of soda waterglass into the crevices. He could not employ potash waterglass equally well, since it was not so liquid, and did not penetrate into the fissures.

"The question will be asked, which of the several kinds of waterglass answers best, and is the most suitable for practical purposes. Nothing definite can be stated as yet. It is possible that the potash waterglass, which sets more rapidly than soda waterglass with powdered substances with which it is mixed, may impart greater solidity to them than soda waterglass; the difference however cannot be considerable. On the other hand, the soda waterglass has the advantage of being more liquid, and penetrating more readily into the smallest spaces, pores and fissures, than the slightly gelatinous and difficultly soluble potash waterglass, a property which is of some importance to the sculptor and mason. Soda does not combine so strongly with silica as potash, and has a strong inclination to efflorescence when combined with the carbonic acid of the air; and one of the advantages of soda waterglass might be due, therefore, to its parting readily with the silica, and thus accelerating the silicatisation of the mass. Further experiments, however, are required to prove its superiority.

"The double waterglass seems to unite the properties of the other two, and merits preference, for the very reason that it contains two bases (potash and soda) with which silica (which prefers to form double compounds) combines more powerfully.

"The fixing waterglass is used for the particular purpose already stated, but it can also be employed in many other cases, especially in painting.

"The first three kinds of waterglass, when completely saturated with silica, are always more or less cloudy or opaque, owing to undissolved and very finely divided silica.

"In order to deprive them of this opacity, it is sufficient to add a little liquor silicum, and to allow them to stand for about a day, stirring them occasionally. The opacity disappears completely, and the liquid becomes perfectly clear, provided it be not accidentally coloured by some other (organic) substance."

We purpose recurring to this important question on some future opportunity.

ST. JOHN'S CHURCH, HIGHBRIDGE, SOMERSETSHIRE.

This church, which is prettily situated in the parish of Burnham, on the coast of the Bristol channel, was consecrated on the 20th of last month. It has been erected solely at the expense of Mrs. H. Luttrell, of Badgworth Court, to meet the requirements of a rapidly increasing population at the newly-opened inland communication: a regular steam service now established with South Wales having caused Highbridge to become an important port.

The plan of the church consists of a nave of five arches in length well proportioned,—and chancel, the former having also an aisle, and the latter a chapel attached. The tower is placed at the north-west angle of the church, and contains four bells, by Warner, of London; its lower stage serves as a principal entrance to the church. Provision is made for the erection at some future time of a south aisle, to correspond with that of the north. The peculiar feature of the interior is the treatment of the nave arcade, the arches of which have a square soffit enriched with running ornament; this soffit is of the whole thickness of the wall, except that a small roll moulding takes off the squareness of the angles. These arches spring, not as usual from simple pillars, but from too small coupled columns placed transversely to the direction of the wall above. The small size of these columns (only 7 inches diameter) and the beauty of the material, which is polished Babicombe marble, impart a rich and elegant effect, as excellent as it is novel; while it has the further advantage of intercepting the view far less than by the ordinary arrangement.

Externally the walling of the church is constructed of blue limestone, procured from quarries at Weston; the relieving arches and banding are of red sandstone from Mount Radford, near Bridgewater. Combe Down stone is used for the dressings, and the roofs are covered with blue and red tiles laid in alternate colours. The pulpit is of stone, and has its upper part enriched with encaustic tiles, while emblems and monograms, inlaid, adorn the several faces.

The font is handsome, and supported on four marble columns. Portions of the woodwork, such as the seating, doors, and screens, have been executed in chesnut, oak being used in the chancel stalls.

The works have been ably carried out from the designs of the architect, Mr. Norton, by Mr. Palmer, of Weston-super-Mare, who has also built, under the same direction, the adjoining parsonage-house. The church accommodates at present 360 persons, and has cost about £2500; the erection of the house cost only £900.

NOTES ON STATICS.

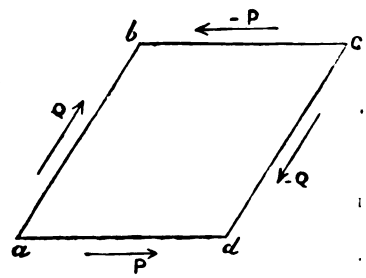
After having proved the theorem of the Parallelogram of Forces, and a few propositions that immediately flow from that theorem, it is usual to demonstrate the principle of the lever, and to deduce from the latter principle the properties of couples. This method however involves, so to speak, a great waste of demonstration, and the following sketch seems to us to indicate a mode of proceeding both more simple and more philosophical.

After having proved *the Parallelogram of Forces*, we proceed to define a couple to be a system of two equal parallel and opposite forces acting respectively at two points rigidly connected, the arm of the couple to be the distance between the two forces, and the moment of the couple to be the product of the arm and the force. We assume that a force acting on a rigid body may, without altering its effect, be transferred to any point of its line of action.

A couple may be denoted by (P, *a b*, —P) or by (P, *a b*) where P and —P are the two forces, and *a* and *b* are any two points of their respective lines of action.

If then on turning from the direction of *a b* round to that of —P, or from the direction of *b a* round to that of P, we are proceeding in the positive direction of revolution, the couple and its moment are called positive, and in the opposite case negative. Couples which are both positive or both negative, (if both in the same plane), may be called similar couples; and couples in the same plane of which one is positive and the other negative may be called opposite couples.

Let *a b c d* be a parallelogram; let *a d*, *a b* represent respectively two forces P and Q, and *c b*, *c d* two equal parallel and opposite forces —P, —Q; then those four forces are in equilibrium; since the resultant of P and Q is represented by *a c*, and that of —P and —Q by *c a*.



But the four forces constitute two couples (P, *a b*, —P) and (Q, *b c*, —Q); the moment of each couple is evidently measured by the area of the parallelogram, and therefore the couples are equimomental, and they are also opposite to one another.

The converse of the above may be easily shown.

Let (P and —P), (Q and —Q) be two equimomental opposite couples in the same plane; then if the forces of the one couple be

Digitized by Google

not parallel to those of the other, their lines of action if produced will meet and form a parallelogram $a\ b\ c\ d$. Let the arm of the couple (P and −P) be p, and the arm of the other couple be q; then since the two couples are equimomental we have

$$Pp = Qq.$$

But, $$ab \,.\, q = \text{area of } a\ b\ c\ d = ad \,.\, p$$

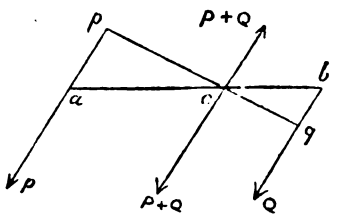
$$\therefore P : Q :: ad : ab;$$

and therefore by the former proposition the two couples balance one another.

Whence it follows that a couple is equivalent to any other equimomental and similar couple in the same plane, provided the forces of the one couple meet those of the other; and if the forces of the two couples are parallel to one another, then by comparing each with an equimomental couple, the forces of which meet those of the other couples, we see that also such two couples are equivalent to one another. We have thus proved the proposition, that a couple is equivalent to any other equimomental or similar couple in the same plane.

From the above follows at once the principle of the lever.

Let P and Q be two parallel forces acting at a and b respectively; draw ab, and on it take c, such that $P \,.\, ca = Q \,.\, cb$. Draw pcq perpendicular on the direction of P and Q. At c apply forces P+Q and −(P+Q) parallel to P and Q. Then P at a and Q at b are equivalent to P+Q at c, and two couples namely (P, ac, −P) and (Q, bc, −Q); and since $cp : cq :: ca : bc$ $\therefore P \,.\, cp = Q \,.\, cq$; therefore the two couples are equimomental, and being opposite couples and in the same plane balance one another. Therefore P at a and Q at b are equivalent to P+Q at c; which is the principle of the lever.



We may show at once in the usual way that as two similar equimomental couples in the same plane balance one another, therefore the resultant of any number of couples in the same plane is a couple having for its moment the sum of the moments of the given couples, the moments being affected with their proper signs; this namely becomes evident by substituting for the given couples respectively equimomental couples having all one and the same arm equal to unity.

Since a force P at a is equivalent to P at a, and +P and −P at any other point O, it follows that P at a is equivalent to P at O, and a couple (P, aO, −P), or a couple whose moment is Pp, p being the perpendicular from O on P at a. If therefore any number of forces PP′...in one plane act on a body, and O being a point in that plane, pp'... are the perpendiculars respectively from O in the direction of the forces, it is easy to see that the given system of forces is equivalent to the resultant of PP′... transported without altering their directions to O, and to a couple whose moment equals $\Sigma(Pp) = G$ say.

If $\Sigma(Pp) = G$ does not equal zero, then the couple may be transferred to O, the point where R the resultant of PP′... acts. Now for this couple we may substitute another one having at O a force −R; then the other force of the couple will be R acting at A, A being such that Oa is perpendicular on R and is equal to $\frac{G}{R}$

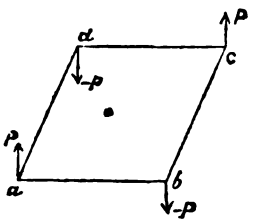
To this force R, then, the system is reduced. Let now Pp be called the moment of the force P with respect to O, then the resultant of a system of forces in one plane is either a couple whose moment equals the sum of the moments of the forces, or a force R having for its moment the sum of the moments of the forces; or finally the system is in equilibrium.

If P, P_1, P_2...be parallel forces acting at points a, a_1, a_2...respectively of a straight line O, a, a_1..., and if the resultant ΣP of the system passes through h a point on that straight line, and is at a distance r from O, we must have $Rr = \Sigma Pp$, or as $r\ p, p_1$ &c. are clearly proportional to Oh, Oa, Oa_1..., respectively we have.

$$R \,.\, oh = \Sigma P \,.\, (Oa) \qquad \text{.....(A)}$$

$\therefore Oh$ is independent of the direction of P.

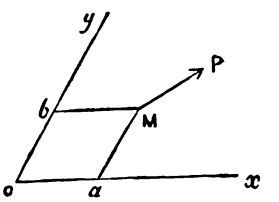
Now let $abcd$ be a parallelogram. Let P, P be equal parallel forces acting at a and c respectively, but not necessarily in the plane of the parallelogram. Let −P, −P be equal and parallel forces opposite to the former and acting at d and b respectively; then since P at a and P at c have for their resultant 2P at the centre of the parallelogram, and −P at d and −P at b have for their resultant −2P also at the centre, it follows that the four forces are in equilibrium, and adding to that system a force P at b, we see that P at b is equivalent to −P at d, and P at a, and P at c. So that we have the following proposition, which will prove to be a very useful one:



A force P *at a point* b, *is equivalent to the force* P *transferred to any two points* a *and* c, *and a force* −P *at the other extremity of the diagonal of the parallelogram constructed on* ba, *and* bc. (B)

From the above we may at once deduce the property of the centre of parallel forces in one plane.

Let P be a force at M. Let Ox, Oy be co-ordinate axes, $Oa = x$, $Ob = y$; P at M is equivalent to P at a, P at b, −P at O; and proceeding in the same way with any number of parallel forces, we find according to proposition (A) the system to be equivalent to $-\Sigma P$ at O, $\Sigma(P)$ at h on Ox where $Oh = \frac{\Sigma Px}{\Sigma P}$, and to ΣP at k on Oy where $Ok = \frac{\Sigma(Py)}{\Sigma(P)}$; and these three forces are by the preceding proposition equivalent to ΣP at the point whose co-ordinates are h and k, a point therefore independent of the direction of the parallel forces.



We proceed now to a system of forces not in the same plane.

Let us first explain a notation which it will be sometimes found convenient to use.

(P) + (Q) denotes the resultant of forces P and Q.

(−Q) denotes a force equal and opposite to Q, in fact a force balancing Q.

(P) − (Q) denotes the same as (P) + (−Q).

(P) + (Q)=(R) means that R is the resultant of P and Q.

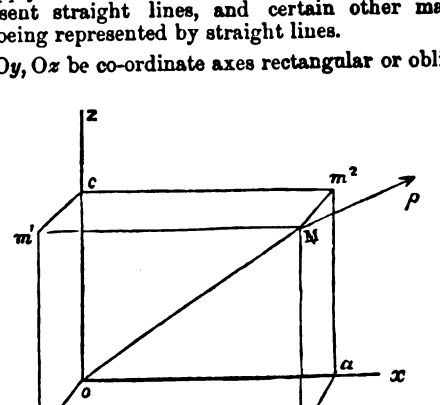
Then it is easy to show that if

$$(P) + (Q) = (R)$$
$$(P) - (R) = (Q)$$
$$(P) + (Q) - (R) = 0;$$

in short, that the ordinary rules for transferring quantities from one side of an equation to another hold good.

We shall therefore call (P) + (Q) *the complete sum* of the forces P and Q, and (P) − (Q) *the complete difference* between P and Q; and shall apply the same terms and definitions to P and Q when they represent straight lines, and certain other magnitudes capable of being represented by straight lines.

Let Ox, Oy, Oz be co-ordinate axes rectangular or oblique, P a force acting at M, whose co-ordinates are $Oa = x$, $Ob = y$, $Oc = z$ Draw Mm_1, Mm_2, Mm_3 parallel respectively to Ox, Oy, Oz to meet the co-ordinate planes at m_1, m_2, m_3, respectively. Let us



Digitized by Google

construct the parallelopiped formed by joining these points. Since $cMOm_3$ is a parallelogram we have from proposition (B) that

$$(\text{P at M}) = (\text{P at } c) + (\text{P at } m_3\,.) - (\text{P at O}).$$

For a similar reason

$$(\text{P at } m_3) = (\text{P at } a) + (\text{P at } b) - (\text{P at O})$$

$$\therefore (\text{P at M}) = (\text{P at } a) + (\text{P at } b) + (\text{P at } c) - (2\text{P at O})$$

Thus we have the following generalization of proposition (B):

P *at* M=P *transported to any three points a, b, c, together with* −2P *at the corner opposite to* M *of the parallelopiped constructed through* M, *c, a and b.*

From this proposition we might deduce the properties and co-ordinates of the centre of parallel forces in space exactly as has been done before for parallel forces in one plane.

Let XYZ be the respective components of P parallel to Ox, Oy, Oz. Let P_x be the projection of P on the plane of yz by lines parallel to Ox, and let P_y, P_z denote similarly the two projections in the other co-ordinate planes. Then P_x is the resultant of Y and Z. Or,

$$P_x = (Y) + (Z)$$
$$P_y = (Z) + (X)$$
$$P_z = (X) + (Y)$$
$$\therefore (P_x) + (P_y) + (P_z) = (2X) + (2Y) + (2Z) = 2P$$

$$\text{Now X at M} = \text{X at M}_1 = \text{X at } c + \text{X at } b - \text{X at O}$$
$$\text{Y at M} = \text{Y at } a + \text{Y at } c - \text{Y at O}$$
$$\text{Z at M} = \text{Z at } b + \text{Z at } a - \text{Z at O}$$

$$\therefore \text{P at M} = \text{X at } c + \text{Z at } a + \text{Y at } a + \text{X at } b + \text{Z at } b + \text{Y at } c - \text{P at O}$$
$$= P_y \text{ at } m_2 + P_x \text{ at } M_3 + P_z \text{ at } m_1 - \text{P at O}$$

That is to say, a force P *is equivalent to the force projected on any three planes together with* −P *at the point of intersection of the three planes.*

And from the above follows at once that a couple (P, MO, −P) is equivalent to three couples (P_y, m_2 O), (P_x, m_3 O), P_z, m_1 O).

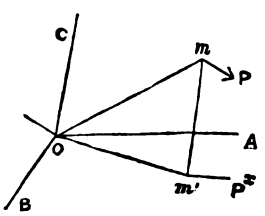
Moreover since P at M = P at O and a couple (P, MO, −P), we can easily see that a system of forces PP_1 P_2, &c., is equivalent to the forces transferred to O, and to three couples in the co-ordinate planes, which couples may be respectively denoted by

$$L = \Sigma(P_x, m_1\ O) \text{ in the plane of } yz$$
$$M = \Sigma(P_y, m_2\ O) \quad ,, \quad zx$$
$$N = \Sigma(P_z, m_3\ O) \quad ,, \quad xy$$

Whence follow the ordinary analytical formulæ.

By means of the above we may also solve the following problem:—

It is required to decompose a couple (P, MO, − P) into three couples in three given planes, BOA, BOC, COA.



The couple in the plane BOA is found by projecting the force at M on the plane BOA by lines parallel to CO. Let such projection be P_x at m_1, then the required couple in the plane BOA is (P_x, m_1 O, $-P_x$); and similarly for the other planes.

ON A NEW FORM OF TELEGRAPH CABLE INTENDED TO REDUCE THE EFFECTS OF INDUCTIVE ACTION.*

By J. N. Hearder, Electrician, Plymouth.

In relation to the existing Atlantic cable, the only assistance which it could possibly afford, would be in very slightly improving the character of the earth discharge. I here avoid the term earth-circuit, because I do not believe that, except under very peculiar circumstances and within very limited bounds, any appreciable return current takes place through the earth. We must indeed look upon the earth as a great reservoir, capable with proper arrangements of affording any supply, or of disposing of any discharge. If the Atlantic cable were a tube carrying water instead of electricity, receiving it at one end and discharging it at the other, it would never be assumed that the portions discharged in America would flow by a return current back through the ocean to supply the other end; and the cases are precisely similar,—the earth acts the part of a reservoir with regard to electricity as much as the ocean does with regard to water; and the circumstances under which return currents either of water or electricity could be produced, would bear the same analogy to each other. The only benefit, then, which the present wire could confer, would be by improving to a certain extent the conducting character of the earth, or in other words, by increasing its capacity to receive the discharge, or afford the necessary supply. I am free to admit, however, that with the present wire the amount of assistance that would be afforded might be limited from its very inadequate conducting capacity. With a capacious insulated return wire, however, the case would be different. It would, as I stated in my last paper, lessen the amount of induction by decreasing resistance, and consequently obviating the necessity of employing currents of high tension; but it must not be inferred from this that inductive action would not take place at all. The two cables would, in fact, when carrying reverse currents, represent two Leyden jars oppositely charged, and with their outer coatings in conducting communication with each other, or as is actually the case, both uninsulated.

I have been led to the conclusion that an insulated return wire would be preferable to an earth-circuit. Induction between the two cables, it is true, cannot be prevented; but it will be much less, as I have already shown, with two separate cables than with two wires included in the same sheath. I have been thus explicit, because the tendency of some scientific discussions which have lately taken place has been rather unfavourable to the recognition of this principle; and whilst I would not dogmatically enforce my views, yet I think they would bear the test of trial.

The success of the foregoing plan, however, would be, after all, only palliating the evil without removing or mitigating the cause; and I would now therefore direct attention to a new form of cable, intended to reduce not only the amount of static inductive action on the dielectric, but the degree of disturbance produced by the residual static discharge.

Since resistance in wires requires the employment of intensity in currents to overcome it, it follows that the greater the intensity of the current, that is to say, the greater the amount of free statical electricity accompanying the dynamic current, the greater will be the tendency to charge the dielectric. Now any increase of charge on the dielectric will produce results in discharge as the squares of the quantities thus taken up. Upon this principle I propose to use a capacious conductor, which shall diminish resistance as much as possible, and thereby reduce correspondingly the intensity of the current requisite to work through it, and its tendency to charge the dielectric.

Since the quantity of charge which can be taken up by any dielectric will depend upon its thinness, or the contiguity of the conducting surfaces between which it is included, I propose to increase the thickness of the dielectric or insulating coating, and thereby not only still further reduce its tendency to charge, but increase its insulating faculty. There are, however, other conditions which interfere still more with the results of discharges from coated surfaces which have been hitherto overlooked, but which may nevertheless render essential service in their judicious application to the insulation of a submarine conductor.

If a Leyden jar or a coated glass plate have layers of paper or any other fibrous material inserted between either or both of its coatings and the glass, although the glass may, as far as the phenomena of tension or attraction are concerned, be charged to the same intensity, yet the effects of the discharge suffer an extraordinary diminution.

Without going into detail upon the results of each modification of the arrangement, it may be sufficient to state that, whilst with the ordinary tinfoil coatings a given effect was produced, only $\frac{1}{10}$th to $\frac{1}{100}$th of the effect was obtained when the porous layers were interposed; and this diminution of effect bore no apparent relation to the conducting or non-conducting character of these media.

Reasoning upon these results, it occurred to me that, in addition to the advantages before alluded to to be derived from increasing the thickness of the dielectric and the capacity of the conductor, still further benefit would result by adopting some modification of the foregoing arrangements in relation to the cable. The interposition of porous or fibrous media between the coatings and the jar or glass plate, reduces the effects of the discharge; and since it is the discharge, more than the charge, which produces the embarrassment of signals, it appears a fair deduction that any arrangement which will reduce the effect of this discharge, will to the same extent diminish the amount of mischievous influence.

* Abridged from a Paper read at the Plymouth Institution.

Digitized by Google

Four modes of carrying out the conditions of the foregoing experiments with regard to the cable, presented themselves. 1st. By inserting a porous layer between the dielectric and its inner coating (the wire), which could be done by covering the wire with cotton, silk, or worsted, or any fibrous substance, previously to coating with gutta-percha. 2nd. By putting a fibrous coating of this kind over the gutta-percha covering of a wire already insulated in the ordinary way, taking care, of course, to make this coating impervious to moisture. 3rd. By inserting the porous or fibrous media between the layers of gutta-percha; or 4th. By adopting two or more of these processes in conjunction with each other.

With regard to the first process, I found from actual experiment that when the conducting wire was very small, as, for instance, in the Atlantic cable, the application of a porous covering to it previously to the gutta-percha coating unduly increased its bulk in proportion to its original size, and thereby proportionally increased the inner charging surface of the gutta-percha. But even under the most unfavourable circumstances, when for the sake of experiment a double coating of fibrous material had been put on, and the inner surface of the gutta percha increased to nearly three times its original dimensions, whilst the thickness of the gutta-percha coating itself was less, thereby enabling it to take up more than double the amount of static charge, yet the effects of the discharge were no more than from the original surface in contact with the wire: so that if only the same amount of charge had been thrown in, less than half the original effect might have been expected.

Since however, according to the experiments with the glass plate, the porous material was equally effective on the outside, or between two plates, it would appear that the most eligible situation for the fibrous layer in the cable, would be either between the coatings of gutta-percha or externally to them; and I doubt not that in either of these situations it would act with the cable, as with the glass plates, in materially reducing the effects of the discharge.

There are also other considerations of a mechanical character which render these modifications of the arrangement preferable. I venture then to recommend, with considerable confidence, the adoption of this plan as a simple and efficient mode of greatly reducing—I will not go so far as to say entirely obviating—the embarrassing influences of the residual discharge.

In a word, a cable constructed upon the principles here laid down will possess the following electrical qualification, viz.—

Its conductor will be of ample dimensions, thereby reducing the tendency to produce static induction.

The dielectric or insulating coating will also, by its increased thickness, not only improve the insulation, but have a diminished capacity for taking up inductive charge; and, lastly, the insertion of the fibrous substance will go very far to obviate the mischievous effect of any amount of charge that may be taken up, since by analogous arrangements we find that from 80 to 90 per cent. of this influence may be intercepted.

I cannot close this paper without alluding to the mechanical advantages also possessed by this form of cable. It is well known that when the gutta-percha coating of a cable is subjected to great strain, small fissures, before imperceptible, gradually become apparent from the separation of surfaces between which there was previously a want of perfect cohesion, although without this strain the cohesion might have been sufficient for electrical insulation, and the fissures might not have been formed. I have no doubt that the Atlantic cable has suffered in this manner, since it had no provision for preventing the gutta-percha from stretching.

Propositions have lately been made to form the core in such a manner as to take all the strain; but independently of the most serious electrical objections to a conductor compounded of iron and copper, I venture to predict that whenever such a cable shall be subjected to the strain of passing over pulleys, the gutta-percha coating will separate into pieces and slide over its included conductor. The interposition, however, of flax or hemp strand, which is a very eligible material, and which may be either braided on or laid on in a very long twist between the layers of gutta-percha and incorporated with them, will communicate such an amount of mechanical strength to the insulating coating, that, in addition to its improved electrical character, it will be free from the disadvantages before alluded to when not thus protected. The specific gravity also of such a cable may be made, if necessary, extremely low.

When made of the requisite dimensions, it need not weigh more than 6 cwt. per mile in air, or 1 cwt. in water; and, from experiments made with a sample of an analogous construction, the breaking strain would be upwards of 17 cwt., or equivalent to between seventeen and twenty miles of its own length in water. It will be remembered that the Atlantic cable would not support three miles of its own length in water; and I question much if the integrity of the gutta-percha coating could be depended upon under the strain of a single mile.

These are considerations which, I would venture to submit, are of no mean importance, even when viewed apart from any electrical qualities, but which, when taken in connexion with those already described, appear to me to give to this form of cable a decided superiority over any form yet devised. I say nothing of any subsequent coating of wire, &c. for additional protection in exposed situations, when found to be necessary, as such an arrangement is as applicable to this form of cable as to any other.

TRIAL OF RUSSIAN DESPATCH VESSEL SOUKSSOU.

THE Soukssou is one of two despatch vessels (built by Mr. Pitcher at Northfleet Dockyard) for the service of the Russian Government.

At the trial in the river Thames, on Saturday the 4th ult., the results obtained were of so satisfactory a nature that they will be interesting to all connected with marine engineering.

The machinery of the Soukssou, manufactured at the Steam Factory, Northfleet Dockyard, is on Harman's patent horizontal direct-acting principle, and was constructed and fitted on board under the superintendence of Mr. C. Sage, from drawings prepared by Mr. Edward A. J. Buckland. In these engines the cylinders and condensers are arranged horizontally athwartships; there are two piston rods to each engine affixed to a cross head working on suitable guides, from which the connecting rod returns to the crank pin through an opening or aperture cast in the condenser for that purpose. The whole of the pumps (which have india-rubber disc valves, with metal guards and seatings,) are worked from the before-mentioned cross head, and consequently have the same stroke as the pistons. The boiler of the Soukssou is of the multitubular description, with brass tubes; it has a fire-bar surface of 54 feet, and a total effective heating surface of 1246·1 square feet=20·77 square feet per N. H. P. The propeller is a double-thread left-handed screw of the dimensions given beneath. During the whole time of the trial there was an entire absence of vibration either in the engines or vessel, which in screw engines running at high velocities is unusual. Such a thing as a hot bearing did not occur during the trial.

The following is a summary of the principal dimensions, performance, &c.:—

Length on load water line	121 ft. 10 in.
Breadth on ,, ,, ...	20 ,, 3 ,,
Draught on trial (mean)	9 ,, 3¾ ,,
Tonnage, builder's measurement	269 tons
Displacement at time of trial	288·5
Area of immersed midship section	123·5 sq. feet
Nominal horse-power of engines	60
Indicated ,, ,, ...	253·7
Diameter of cylinders	28 inches
Length of stroke	15 ,,
Diameter of propeller	7 ft. 9 in.
Pitch of ditto	11 ,, 0 ,,
Length of ditto	0 ,, 19 ,,
Number of revolutions (mean)	110
Mean speed of ship, in knots per hour	10
ditto propeller, ,, ...	11·93
Slip of propeller, ,, ...	1·93
ditto per cent.	16·1
Nominal horse power to midship section ...	0·486
Indicated ,, ,, ...	2·054
Area of screw's disc to midship section ...	2·616
Co-efficient of locomotive duty by formula $\frac{\sqrt{3}a}{\text{I.H.P.}}$	486·8
Co-efficient by formula $\frac{\sqrt{3}a}{\text{N. H. P.}}$	2058·3
Weight on safety-valves in lbs. per square inch	20
Mean vacuum in condensers	25 inches
Mean steam pressure (at mile)	18 lb.
Quantity of coal on board at trial	38 tons

Digitized by Google

THE ATLANTIC TELEGRAPH CABLE: CAUSES OF FAILURE, AND PROBABILITIES OF ULTIMATE SUCCESS.*

Communicated by Lieut. MAURY, U.S.N., in a Letter to JOHN LOCKE, M.R.D.S.

"National Observatory, Washington, Dec. 1858.

"DEAR SIR,—Your letter of the 9th instant, with a printed slip containing suggestions with regard to lines of submarine telegraphs, has been received. Several persons have done me the honour to submit plans for laying telegraph wires across the sea. Most of these plans seem to be based on the supposition that the cable which now lies a mere rope along the telegraphic plateau, is the *kind* of cable to be used hereafter. This is a mistake; for the true nature of the *Neptunian* obstacles to the enterprise of 1857-58 have not, it appears to me, been rightly appreciated. I leave out of view for the present all questions relating to the electrical conditions of the problem, and address myself exclusively to the Neptunian difficulties with which the projectors of any line of telegraph across the Atlantic Ocean will have to contend; for, had the true nature and extent of these difficulties been properly considered by the London Company, I have no doubt but that the Atlantic Telegraph would at this day have been in successful operation.

"The system of deep-sea soundings which was inaugurated in the American navy about ten years ago, and in which the navies both of England and France have participated with signal success, has led to a series of discoveries of the highest importance to submarine telegraphy. The facts which these soundings have brought to light concerning the status of the deep sea are such that, when properly considered by the hydro-telegraphic engineer, will render lines of submarine telegraph as cheap, if not cheaper, than our overland lines are. A full account has been given of these discoveries in my work on the 'Physical Geography of the Sea,' and in the publications of this office, the most recent of which are contained in vol. i., 8th edition, 'Maury's Sailing Directions.'

"In stating these facts, and the results derived therefrom, let us in the first place confine our attention to 'blue water.' It is an established fact that there is no running water at the bottom of the deep sea. The agents which disturb the equilibrium of the sea, giving violence to its waves and force to its currents, all reside near or above its surface. None of them have their homes in its depths. These agents are, its inhabitants, the moon, the winds, evaporation, and precipitation, with changes of temperature—heating here and cooling there.

"The rays of the sun cannot penetrate into the depths of the ocean, and radiation cannot take place there; consequently, the change of temperature in the depths of the sea, from summer to winter and from winter to summer, must be almost if not entirely inappreciable. This is a generally admitted fact.

"The winds take up, in vapour, fresh water from the surface, and not from the depths; and in so doing they disturb the equilibrium of the water at the top, not the equilibrium of the water at the bottom: for by evaporation the surface water becomes salter and heavier than it was before. The vapour thus taken up is condensed into rain, and precipitated on other parts of the sea, thus raising the sea-level, and making the water lighter and less salt than it was before. Thus we have the genesis of a horizontal circulation, or an interchange of water, which we call currents. If by the process of evaporation the surface water becomes so salt as to be heavier than the water at the bottom, the water at the bottom and the water at the top will change places. This may give rise to a vertical circulation, but one so feeble that it cannot be felt by even the tiny little shells which strew the bed of the ocean, and which lie there as lightly as gossamer under the dew of the morning. Practically, therefore, the water at the bottom is still.

"It is also generally admitted that the waves, even in their most angry moods, are incapable of reaching far down in the sea, or of disturbing the quiet and repose which reign in its depths.

"In short, there is reason to believe that the bottom of the deep sea is everywhere protected from the violence of its waves, the abrading action of its currents, and the rage of the forces which are ever at play upon its surface, by a cushion of still water.

"The grounds for this belief are afforded by these circumstances:—Everywhere, whencesoever specimens of bottom have been obtained by the deep-sea plummet, they have been found to consist of the untriturated remains of the microscopic organism of the sea; some of these have the flesh of the little creatures still in them. Now these feculences of the sea, as the remains of its microscopic inhabitants may be called, are relatively as light in the water as motes in the air; and if the bottom of the deep sea were scoured by its currents, these *sea-motes* would be swept away into drifts like snow, or into dunes like sand. They would bear the marks of water-wear upon them; they would be scratched; their sharp corners and their edges would be broken off and rounded; moreover, were they drifted about, then sand and other scourings of the bottom would be found mixed with them. But not so: the specimens brought up from the deep sea show no such mixture, and the Infusoria thence bear no marks of abrasion upon even their most delicate parts. Indeed, some of them are so fresh, still having the meat of the animal in them, that Professor Ehrenberg of Berlin, with others of the '*Biotic*' school, maintains that these shells live at the bottom of the deep sea, whence the sounding-rod recovered them.

"The '*Anti-Biotics*,' on the contrary, maintain that these shells live and die at or near the surface, and are buried on the bottom and bed of the ocean; that the antiseptic properties of sea-water tend to prevent decay in the first instance, and, as the dead animalculæ continue to sink, the pressure of the superincumbent water prevents chemical decomposition; and consequently, they of this school hold, and rightly hold, I think, that so far from admitting that any of the abrading forces of water, which are so familiar to us, are harboured in the depths of the ocean, or that they can find room for play there—they maintain that the hand of decay itself becomes, when stretched forth in the chambers of the deep, so palsied as scarcely to be able to make itself felt, even upon the most perishable things there.

"The pressure upon the telegraphic plateau varies from 200 to 300 atmospheres; that is, from 430,000 to about 650,000 lb. the square foot. Chemical forces may be measured, and consequently overcome, by pressure; for the gases generated by chemical decomposition are themselves capable (so the chemists tell us) of exerting in the processes of that decomposition only so much pressure. Hence, if we subject them to a greater pressure, they cannot separate, and decomposition cannot take place. In proof of this, I refer you to a recent discovery by Ehrenberg. In the specimens obtained at a great depth from the Mediterranean, that celebrated microscopist has distinctly recognised fresh-water shells with meat in them.

"From this beautiful little fact we may infer that the very volatile gases which enter into composition for the formation of the fleshy parts of marine animalculæ are there subjected to such a pressure upon the bed of the ocean that they *cannot* separate. If this inference be correct—and it doubtless is—may we not proceed a step further, and conclude, with reason, that with the pressure of the deep sea upon it the gutta-percha used for insulating submarine wires becomes impervious to decay?

"With a due appreciation of these facts and circumstances, we are now prepared for the question which involves most of the *Neptunian* difficulties with which the Atlantic Telegraph Company has been contending with their cable; and the question (such being the facts) may be thus stated:—Is not any cable, that is heavy enough to sink, strong enough to lie on the bottom of the deep sea? If yea, then tell me why have any *Atlantic* 'CABLE' at all? Why serve gutta-percha cords at all for the deep sea with *iron wire*? I am not speaking of the shore-end, where the water is shallow, where abrading forces *do* work, and where the iron service is required; but, as I said, my remarks relate to the deep sea, and I speak of the cable for *that*.

"Of what use to the cable was that iron coat of mail in which the insulated conductor was encased? Was it to make the cable sink? Why, the company found the cable so heavy when they began to pay it out into the deep sea, that they were constrained to postpone the undertaking from 1857 to 1858, that they might tax the ingenuity of the world for brakes and paying-out machinery that would prevent the cable from parting by its own weight, when running out in deep water. Without the iron coating it was heavy enough to sink; and if it were not so, a little larger conducting wire in the centre would have made it so, without any *injury*, I apprehend, to the *electrical* capacity of the cord. Many have proposed buoys for the cable. What a simple substitute for buoys would it be to leave off the coating of iron wire! Had that been left off, there would have been no need of 'brakes'

* Paper read before the Royal Dublin Society.

Digitized by Google

and much other machinery that the cable required on account of its cumbrous coat of mail.

"Bearing in mind the quiet which reigns at the bottom of the deep sea; that the bed of the ocean is protected from the abrading action of its currents by a cushion of still water; that there is no running water down there, and that the pressure is such as to obstruct, if not for ever to prevent, the decomposition of all animal and vegetable matter when once lodged there,—let us inquire a little more minutely as to the use of that iron wrapping for the deep-sea part of the cable.

"It was not to protect the cable from abrasion after the cable was lodged on the bottom, for we have discovered that there are no abrading forces there to fret it.

"It could not have been to keep the cable down, for we have seen that the lightest dregs that float in the water are, when allowed to settle on the bottom of the deep sea, heavy enough and *strong* enough to remain there.

"It could not have been on the score of economy, for the cost of the cable must have been nearly, if not quite, doubled on account of the iron wrapping.

"The wrapping of iron wire without does not, I imagine, tend to *improve* the conducting powers of the copper wires within; and besides the cost and the difficulty of manipulation, owing to increase of both size and weight which this iron wrapping gives the cable, that increased size and weight have, I imagine, something to do with the real cause of the electrical difficulties of the cable. What the real nature of those difficulties is, must be matter of conjecture; but the conjecture which seems to me most plausible is one of this sort:—The conducting wire is a strand of seven copper threads twisted together. This strand is then coated with gutta-percha, making a straight cord about the size of a lady's finger. This cord is then served with eighteen strands of iron wire, consisting of seven threads each, wrapped spirally about it. Now, in the process of paying out in the deep sea, and in holding back, the strain of the two or three thousand pounds which was brought to bear upon the cable, in order to prevent it from running out too fast, was first borne principally by the straight cord, consisting of the gutta-percha and the conducting wire, rather than by the spirally laid iron wires.

To illustrate this proposition, namely, that the strain was brought to bear upon the straight centre-piece, or heart, as the conducting wire with its coating of gutta-percha may be called, rather than upon the spirally served iron wire, it is only necessary to refer to rigging on board ship that is laid up with a heart-piece or centre strand. The strands of the rope, like those of the iron wire, are laid spirally about the *heart*, and when the rope has been subjected to a strain, 'Jack,' to use his own language, always finds '*the life all gone out of the heart.*' Certainly, a spirally-laid rope yarn or iron wire will stretch more than the one about which it is so laid.

"Such was the strain brought by the brakes upon the cable on board the Niagara, says an eye-witness, that 'large quantities of tar are pressed out of the cable as it enters and leaves the machine, and fall into tubs which are left near the machine for its reception. Of this stuff a couple of ordinary sized barrels-full are collected each day, and thrown overboard.'*

"Here was force enough to impair insulation by stretching, indenting, and cutting the gutta-percha, or to injure conducting powers by stretching and breaking the threads of the copper wire; for as I said, when the Niagara and Agamemnon were paying out this cable last summer in the deep sea, and when the brakes were holding back with the strain of 2000 or 3000 lb. on the cable, the heart suffered first. The gutta-percha would outstretch the copper, and then each wire of the conductor, which consisted of seven small copper threads, was attacked in detail, and thus the strength of the conducting wire was often tried without any perceptible giving way. It was impossible to have the strain to come upon all the threads exactly alike; probably, therefore, first one parted, and then another; so that in the whole distance each one of the seven may have parted may times—sometimes one alone, sometimes several, perhaps all, or all but one or two at the same place; for the parting of any one facilitated the parting of the rest, and all at the same place. One conducting wire would have been better both in an economical, electrical, mechanical, and Neptunian point of view.

"At first the fractured surfaces, with their crystalline points, were bright, and the galvanic current could leap the little chasms with comparative facility; but use tarnished them, and the leaps became more and more difficult. Hence the passage of intelligible messages at first, and their gradual cessation, and the subsequent failure of the cable to give any signs of life. This, however is, as I said, mere matter of conjecture, but it is the most plausible explanation that I have heard as to 'why the cable has stopped working.'

"The first step, therefore, towards success in the establishment of submarine lines of telegraph across oceans is to get rid of the idea of iron ropes and great cables for the deep sea (limit these to shallow water), to divert ingenuity from brakes and buoys, and direct it to cords that will require neither. But some will say that the heat in a ship's hold is often such as to melt the gutta-percha, and therefore an iron wrapping is necessary to hold it together, and so preserve the insulation. The 'Rogers' cord' is a complete answer to this objection. After insulating, he braids the conducting wire, whip-cord fashion, with bobbin or twine, and then protects the whole with a pigment, gum, or cement, which shields the gutta-percha, securing it against chafes, bruises, melting, &c., and still leaves the cord so small and manipulable that one ship may carry the whole of it, and 'pay and go' with it across the Atlantic as fast as though she were making an ordinary passage.

"The specific gravity of this 'Rogers cord' is such as to carry it down at the rate of only a mile or two an hour. Now it is evident that pieces of such cord, if cut into lengths ten miles long, for instance, and thrown into the sea, would find their way to the bottom as readily as pieces of one mile, or of a few fathoms, in length would. And since, at the greatest speed of the paying-out vessel, not more than about ten miles of this cord will at any one time be beween the stern of the vessel and the bottom of the sea, the feat of laying it in lengths of ten miles may be practically accomplished by an artifice; and the artifice consists in paying out the cord with slack enough in every ten miles of it to feed the current, and to spare.

"The common operation of 'heaving the log' may be referred to in illustration of the manner in which the 'Rogers cord' may be laid. In heaving the log a certain quantity of what is called 'stray line' or 'slack' is always paid out. This new cord is not larger than a common log-line. And the line between Varna and Balaklava, which worked so well in the Black Sea, was, I have understood, paid out by hand. It was simply a copper wire, insulated with gutta-percha, and without any other covering. If such a wire could be laid in the Black Sea, one could be laid in the *deep* sea as well; for there is reason to believe that the currents of the ocean do not extend beyond a few hundred fathoms in its depths.

"There seems to be a sort of general impression that the amount of slack cable required to feed the currents of the sea is very considerable. A little reflection will show that this is not the case, especially along the telegraphic plateau.

"The current which requires the greatest proportion of slack is one which sweeps across the cable at right angles; whereas the great circle along which the Atlantic cable was laid crosses the Gulf Stream so obliquely, that practically a vessel running from Newfoundland to Ireland may be considered as running with that stream for much of the way.

"The current along the telegraphic plateau seldom exceeds two knots an hour; it rarely amounts to that. But to present the strongest case against the view I am advocating, let us suppose that the current there runs all the way across at the rate of two knots, and at right angles to the cable, and that a vessel, with the proper length of the Rogers' cord on board, were to set off, 'to pay and go' with it from Newfoundland to Ireland; the cord, being paid over with 10 per cent. of slack, is heavy enough to sink at the rate of two miles an hour. The current, let it be supposed, extends to the maximum depth of half a mile; any given part of the cord, therefore, as it goes out and sinks at the rate of two miles an hour, occupies fifteen minutes in sinking the first half mile. During these fifteen minutes only it is exposed to the current, by which it is swept half a mile to the right or the left of the track of the ship; then, reaching the still water below, it settles down through it until it reaches bottom.

"Thus in the case supposed the cord would lie, not in a zig-zag, but in a line all the way across, and only half a mile to the right or the left of the path actually made by the keel of the ship. The difference in distance by such a path and such a line would be practically unappreciable; and yet the case supposed is an exaggeration of the case that is actually presented. For a part,

* Mullany's 'Telegraphic Cable,' p. 264.

Digitized by Google

if not for the entire distance, there is an under current which would bring the cable back towards the direct line, thus tending to counteract the effect of the upper current in sweeping it off.

"In confirmation of these views, and of the existence of that cushion of still water at the bottom, I bring in for further evidence the testimony afforded by Commander Dayman, R.N., while running his line of deep-sea soundings along the telegraphic plateau in H.B.M.S. Cyclops.

"On one occasion he hauled up from the bottom a coil of 200 fathoms of deep-sea line; it had been laid at the bottom, round and round, in a coil, with as much regularity as it could have been coiled on deck by hand: thus showing that either there was no current there at all, or that the upper and under currents so nearly counterbalanced each other, that the line passed perpendicularly, or nearly so, through the still water.

"The tiny nautilus rides out the hurricane and weathers storms in which the stoutest men-of-war have foundered; and in order to make progress in submarine telegraphy, we must proceed upon the principle that *a slack line in the sea will hold longer than a taut cable*, for the forces of its waves and its currents are not to be overcome by such powers of resistance as human fabrics have the strength to offer.

"I have no doubt whatever as to the ultimate success of a telegraph across the Atlantic. Indeed, the only limit to our power to establish at pleasure lines of submarine telegraph is the limit, if any, which Nature herself may have imposed upon the galvanic current. The sea offers no obstructions on account of its depths or its currents to lines of any length. A line with an unbroken conducting wire across the Atlantic or the Pacific, is as practicable as one across the Alps or the Andes. In the long run, and mile for mile, I do not think there would be much, if any, difference as to cost between the two.

"*The real question for future projectors of lines of submarine telegraph is, not how deep, or how boisterous, or how wide the sea is, but what are the electrical limits to the length of submarine lines?*

"You know that England and France, Spain and Portugal, Holland and Denmark, Sweden and Norway, Russia and Prussia, Belgium, Austria, and the Holy See, Sardinia, the Republics of Bremen and America,—indeed, all the maritime states of Christendom,—have joined hands in a general system of research into the physics of the sea; and among the many valuable results which they have already given to the world, the discovery of a way for the lightnings through the chambers of the deep may be regarded not by any means as the least."

SIMPLE METHOD OF CALCULATING EARTHWORK.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

In your May number, A. S. W. describes a method of calculating the contents of cuttings, and asks if it has ever been previously used. I may inform you that the same method has been used by me for some years, but I never looked upon my application of it as a *discovery*, for I thought it would be sufficiently obvious to any person with a slight knowledge of mathematics, who might have frequent occasion to measure irregular solids.

The method was first suggested to me in 1846, when investigating the proper system of ascertaining the cubic contents of walls built to support the slopes of embankments. I was then engaged in forming reservoirs at Whittle Dean, for the water supply of Newcastle-upon-Tyne. The walls of our grating tanks were of the form shown in the two figures: Fig. 1 being an elevation of the wall, and Fig. 2 a section of the same at E.

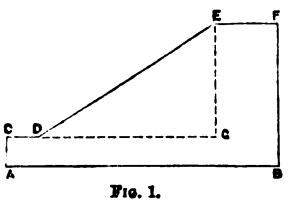


Fig. 1.



Fig. 2.

The upper surface of the walls, or where they coincided with the slope of the embankment, as on CDEF, was of uniform breadth, the face was perpendicular, and the back battering. In measuring the contents of the triangular portion DEG, it seemed at the first glance that a near approximation would be attained by multiplying the length DG, by half the height EG, and this again by an average thickness found by taking one-third of the sum of the thicknesses at the angles. I soon found that not an approximation only, but the exact contents was the result. Subsequent investigation showed me that this method was coincident with, and directly deducible from the prismoidal formula. For let us call a, b, and c, the thickness at D, E, and G respectively, l=the length DG; h=the height EG.

For wider application I take a different symbol for the thickness at each angle. Then "*the sum of the areas of the ends added to four times the area of the middle section, and multiplied by one-sixth of the length will give the contents.*"

$$\text{Area at D} = a \times o = o. \quad \text{Area at EG} = \frac{b+c}{2} h.$$

$$\text{Four times area of middle section} = 4 \times \tfrac{1}{2}\left(\frac{a+b}{2} + \frac{a+c}{2}\right)\frac{h}{2}$$

$$= \left(a + \frac{b+c}{2}\right)h$$

$$\text{Content} = \left[o + \left(a + \frac{b+c}{2}\right)h + \frac{b+c}{2} h\right] \times \frac{l}{6} = \frac{a+b+c}{3} \times \frac{lh}{2}$$

which last expression is the method of A. S. W.

The prismoidal formula admits of very wide application, and I find it useful in calculating the contents not only of cuttings, but of conic and pyramidal frustrums, and in various ways.

T. D. Ridley.

Hexham, May 10, 1859.

ON THE CONSTRUCTION OF DOMES.*

By T. Hayter Lewis.

Having some few years since to erect a dome of very considerable span, I was surprised to find how little practical information existed on the subject. Being thence led to investigate and to make notes relative to domical structures generally, I have now put them together, in the hope that others may also be induced to give the result of their experience and studies respecting this beautiful class of buildings—the most beautiful termination, it appears to me, for any grand architectural composition. In the present paper it would not be convenient to enter into elaborate mathematical investigations. I shall, therefore, merely refer to the principal theories on the subject; describe the construction and the cause of failure of some few of the most celebrated domes; and then try to sketch out some broad principle for adoption.

The theories best known are those of Dr. Robison, of Venturoli, and of Rondelet. Dr. Robison's was, I think, first published in his 'Mechanical Philosophy,' and then re-written by him under the article "Arch," for the 'Encyclopædia Britannica:' it has been referred to in almost every subsequent work on mechanics. From this theory, the particulars of which may be found in the works to which I have alluded, are deduced directly the following somewhat startling results:—that a dome starting from a perpendicular drum could not stand at all; and that a reversed curve is a much stronger form than the usual insistent one. Venturoli's theory is given by him in his 'Treatise on Mechanics,' a very good translation of which has been made by Mr. Cresswell. The results are very much the same as Dr. Robison's. Rondelet's theory is given in detail in his well known work on Construction, and it has been very well condensed in Gwilt's admirable Encyclopædia. It is of a much more practical nature than the others, and assumes that the weight of the upper part, pressing outwards, is counteracted by that of the lower part; the difference of the two forces giving, so to speak, the measure of weakness in the dome.

There is another theory to be found in the well known 'Parentalia,' but to which I should not here allude, were it not almost the only one mentioned in that work; and although it may now appear almost absurd, the author's extended notice of it would induce us to believe that it must have been favourably accepted in his time. It will be found given at considerable length in any edition of the 'Parentalia.' It refers, however, more particularly to arch construction.

Now, I have too great a reverence for the study of mathematics, and I am too sensible of the advantage that our profession derives from that science, to say one word that might appear to

* Paper read at the Royal Institute of British Architects.

Digitized by Google

slight it; and indeed, the great names I have mentioned would prevent my speaking so strongly as I am obliged to think of their theories, had I not found words as strong used by one of the most noted of the authors themselves, Dr. Robison. In one of the articles to which I have referred, he gives an analysis and description of the arch. He puts the theory before his readers in a perfect manner; shows how beautifully the exact size of every stone, and the curve of each arch can be calculated; and, in fact, leaves us quite satisfied that the theory is correct. Then, having made everything so clear, he quietly informs his readers in an equally clear manner that the speculations of all the eminent persons who have written upon it are of no practical value whatever. The fact is, that the most celebrated of these theories assume as a basis that the arch or dome is formed of layers of stone, sliding freely upon each other, without bond, friction, or the interposition of cement—conditions which never have occurred, and which never can occur in actual practice. Moreover, it is really for all practical purposes almost waste of time to deduce calculations for constructing stone domes at all; for, curious as it may seem, I believe that there is not existing, and that there never has been built, any stone dome of very large size, since the time of the Atridæ, at Mycenæ.

The construction we have to consider, if it is to be of any practical use, is of brick, and this material is so combined in execution with cement, that the theoretical joints do not really exist; for with good cement the bricks themselves are as likely to yield as any of the joints. In stone construction the case is different. The thinness of the mortar in the joints makes them really what their name implies, and we should consequently approach near to, though we can never actually realise the conditions of the theory.

Now, in addition to the difference in the materials, we must also remember that the details of construction in the domes now existing vary very much, and that they are by no means to be resolved by one theory. As I propose to notice actual examples only in this slight sketch, I must ask you to examine with me, briefly, the principles of construction of the most noted. The first to which I will allude is the celebrated tomb of the Atridæ, at Mycenæ. I need scarcely mention that it is formed of horizontal layers of stone, in large blocks worked to the form of the curve on the inside only, and without, so far as I am aware, any cement in the joints. It is of considerable size (48 ft. 6 in. in diameter), being about that of St. Vitale, at Ravenna, and somewhat larger than that of St. Stephen's, Walbrook. The construction displays great simplicity, and theoretically no power short of what would actually crush the very stones could, so far as I can see, break this dome. The pressure at every joint is perpendicular, so that there is really no outward thrust, and the tendency of each stone to fall inwards is met and destroyed by the opposite thrust of the other stones. If the task were now given to erect a dome of a pointed vertical section, with large masses of stone, such as the architects used of old, I doubt if a better mode of accomplishing it could be found.

The next examples are those of the well known Pantheon (142 feet diameter) and of the Temple of Minerva Medica (81 feet diameter); baths or temples, as you will. These domes are formed of several ribs of brick, which appear to have been built quite distinct from the filling-in work between them; just as in early Gothic vaulting the various ribs were first formed and set in their place, and then the intermediate light chalk panels added to complete the whole. This opinion as to its construction is confirmed to a certain extent by the way in which we know, to our regret, that the dome of the so-called Minerva Medica has perished. But a few years ago the ribs stood firmly, although a great part of the filling-in between them had disappeared. I believe the same might occur at the Pantheon, and that its skeleton construction is just that of York Chapter-house; so that, without at all altering the leading principles, we might arch the filling-in to steady the ribs, and convert the great dome of the Pantheon into a gigantic resemblance to its graceful little English rival. Whether or not the change would be approved, it is not for me to surmise; but that the vast building would at once display as it never has displayed its enormous size, I have no doubt whatever. Setting however this question aside, it seems to me, that in this greatest and noblest of domes we have the essentially Gothic principle of security by abutment, and not by a tie; for if, as I believe, the stress be borne by the great ribs, the tie to be effectual must clearly be straight from one of them to the other: otherwise, if we put it in the circular form the feet of the ribs would spread outwards until the tie became straightened. But if we fill up the space between the ribs, this filling-in would serve to strut them, and preventing by its circular form the tie from straightening may occasion it to act. If therefore in the Pantheon dome there be any real binding courses, I believe that they act as ties to the ribs only by the filling-in acting as strutting. But I do not believe that the tie exists at all, but that the stability of the dome is secured by the strong abutment only.

The next example is the dome of St. Sophia, at Constantinople, of about 110 feet diameter. Of this we have ample information, beginning with the history of the building so beautifully condensed by Gibbon, down to the recent elaborate drawings and description of Salzenberg. Unfortunately the ancient accounts, so clear and precise, are erroneous in one important particular; for while all state that the dome was finally reconstructed as it stands of pumice stone, or light Rhodian bricks, Salzenberg informs us that no trace of these can be found, and that it is formed altogether of ordinary well-burnt bricks. It appears that the four great piers at the angles of the square on the plan were the only supports at first adopted, and that the pendentives and dome were formed on them. The pressure of the eastern and western arches springing from the great pier was resisted by four walls forming transepts running north and south: against the eastern and western walls respectively abutted two semi-domes. The superstructure having given way towards the east, taking away the semi-dome on that side, the eastern pillars were strengthened, and the dome was again turned, but it gave way again before it was completed. Strong buttresses were then built to the east, and a dome (this time of pumice stone) turned for the third time. But it became cracked and split, the arches under being so fractured that those on the north and south sides required to be filled in with the three-storied arcades now forming such prominent features in the interior. This dome then stood awhile; but it was destroyed by an earthquake, and was subsequently rebuilt.

All this narrative would show that the substructure was the defective part, the great arches not having sufficient abutment; and that whether the dome as first built would have stood or not, not one, however sound in itself, would have stood upon such a base. Whether constructed of pumice stone or of light or heavy bricks, the recent dome seems to be of homogeneous construction, without separate ribs; answering in fact to our ordinary idea of a dome, as typified by the internal brick dome of our own St. Paul's. The general thickness varies from about 2 feet to 2 ft. 6 in. It has strong buttresses as abutments (8 ft. 6 in. thick) above the springing, and the walls under are excessively thick as compared with the thickness of the vaulting.

The next example is the dome at Beejapore. It is formed of a solid mass of brickwork, put together with good mortar: it is 124 feet in diameter, and varies in thickness from 10 ft. 6 in. at a little above the springing, to 10 feet near the top; so that it is four times as thick as that of St. Sophia, with a diameter one-eighth larger. I have few data from which to form an idea of the strength of the material, but I assume the general construction to be on the same principle as that of St. Sophia, but differing from it in weight, thickness, and bearings.

The dome of the Cathedral of Florence is 138 ft. 6 in. diameter, octagonal in plan, with a great rib at each angle, and two smaller ones on each face. These are connected together by a thin casing (about 2 feet thick) outside, and a thicker one (averaging about 7 feet) inside, with tiers of arches turned between the ribs in order to strengthen these casings. At the foot of the dome is a strong tie, composed partly of timber and partly of iron; and the whole mass rises clear above all the surrounding parts of the edifice, showing that the dome is quite self-supporting, and that it derives no strength from external abutments of any sort. It supports a heavy ornamental lantern; being the first great example in which this weight, extraneous to that of the dome itself, has to be supported. Some settlements appeared soon after its erection, but the whole seems to have stood without any serious defect until the end of the seventeenth century, when several fractures appeared for the first time, or were then considerably increased: they are said to have extended through the whole thickness of the dome, to have descended also through the tambour to the main arches, and thence in a clearly traced line down to the ground. It was therefore the opinion of some that the foundations only were in fault; whilst others considered that the dome had opened from lateral extension, thereby burst-

Digitized by Google

ing open the tambour, &c., and that it should be encircled by iron ties to prevent further spread. Fontana was of this opinion, and his advice being adopted, three iron ties were prepared; however, before they were completed, the contrary opinion (advocated chiefly by Nelli) prevailed: the ties were not fixed, and the fractures were merely secured by dovetailed cramps. The present stability of the dome proves that this remedy was effectual.

The dome of St. Peter's, the design of Michael Angelo, though carried out by Fontana, is about 139 feet in diameter, and differs from that of Brunelleschi just described, by being circular instead of octagonal on plan; but like it is formed of sixteen ribs, united together by a double casing, the outer about 2 ft. 10 in. thick in the centre, and the inner 6 feet thick. It stands on a tambour, without abutment at the springing; but a little below it is encircled by a peristyle, not however of mass enough to act in any great degree as a buttress to counteract the spread of the dome; and at the top of all is a heavy lantern. The dome is built of brickwork. Four ties were first inserted, at different heights. These proved ineffectual, the dome becoming very much fractured; and in 1743 two others were added, encircling the tambour and peristyle below the springing. The next year three others were added round the exterior of the dome; one near the top, a second half-way down, and the third at the foot. In 1748 another tie was put round it at some distance above the springing; and this is, I believe the last addition, the dome having appeared to be secure since that time. If my theory of dome construction be correct, this tie is the only one required.

I come now to the important question of the double wall or casing of this and of the Florentine dome. I scarcely know the general idea respecting this system of dome construction, but so far as I have been enabled to ascertain, it seems to be considered a method of obtaining strength by a clever arrangement of the material; much in the same way as we obtain it by casting a given amount of metal into a large hollow column instead of a small solid one.

Now let us try how these domes could be broken, and we shall then get some clue towards calculating their strength. Taking any one part separately it might be bent or broken horizontally, as a bow might be; or it might be similarly broken in its perpendicular section by the weight of the lantern pressing on the top, whilst the bottom was secured by an abutment or tie. This weight would act upon and be resisted by the perpendicular section, in the same manner as in the large boxed iron cranes now used in the docks, &c. For, if we may apply to these magnificent domes so homely an illustration, we may consider each pair of two ribs composing them, with the casings between, as huge bent tubular girders, of almost the same outline as those forming the dock cranes.

Now, any force that we can conceive likely to act as destructive to the dome, would produce a strain on the outer flange or casing tending to tear it asunder, whilst it would endeavour to compress or crush the inner one; we should therefore expect to find (supposing that the great architects who designed these domes adopted the hollow walling for strength) that they had arranged them as we should arrange the metal in a girder, distributing it in different amounts, in proportion to the forces that they have to resist. It is clear, however, that this was not the idea of Brunelleschi, or of Michael Angelo; for the external casing of their domes had no provision for resisting extension, whilst the materials of the internal vaults appear from their thickness to be intended to resist direct compression only.

I know of no other way in which the double vault could be used so as to give strength. It could not be with the notion of obtaining it as we do in a square hollow column; because a direct strain, perpendicular throughout to the direction of its length (an element necessary to the stability of a column) could not be brought upon it. It would, in fact, give way in the curve, as a bow would when pressed at the ends.

Brunelleschi's own description, as recorded by Vasari, seems to give us clearly his idea of the whole, and to show that his plan was to obtain the necessary strength by the ribs, and not at all by the double vaulting. He states that the external vault is necessary in order to protect the inner one from the weather; and he directs that the latter, after it has been raised to a certain height, should be formed of the lightest materials that could be found, whilst the ribs were to be built up throughout of solid stone.

I apprehend therefore, looking at the whole question, that Brunelleschi's idea was to construct the ribs of a certain form and thickness, and then to fill in between these ribs, so as to stiffen them and complete the vault inside and out; leaving a hollow space between, in order to lessen the weight as much as possible. The inside casing both at Florence and at Rome is made the thickest, as it has to bear to some extent the strain of the ties.

We have in England a beautiful example of the way in which stone ribs will stand when the rest of the vaulting has fallen, in the picturesque ruins of Mayfield, one of the most interesting remains in our southern counties. The whole of the ceiling, whatever it may have been, has disappeared, but the ribs still span the width of the great hall strongly and boldly; and with a few cross arches to steady them, and take the strain of the ties, I believe that the grand stone ribs of Brunelleschi's skeleton would do the same.

The last example I shall quote is the dome of our own St. Paul's; the first, I believe, of its type, but the general system of construction of which has been followed ever since. I do not wonder at its being thus copied; for the majestic effect gained in it by its architect has never been surpassed, and the whole composition of the exterior, at least, is to me the most glorious specimen of Italian architecture.

There is no direct abutment to sustain the thrust of its cone, which, contained by its tie, and held together by the general goodness of the work, stands firmly upon the tambour, without exerting any expansive force. I believe that in this cone we have the true secret of domical construction, which shows itself here in its simplest form, unconcealed by the curved outlines which in other cases mask while they adorn the reality. Secure this cone at the foot, and I know of no power that would break it, short of what would crush its materials to powder. Bend the straightness of its side into a curve, so as to enlarge it to the form of a dome, and as the curvature is increased the strength is lessened. Where would this curved dome break? Clearly, if it were weighted at top, and the foot kept from spreading, it would break like a bow, between the two points. Tie in this weak part, and the danger at that part disappears, being transferred to two other points between them.

In this view it will be seen that I look upon the fabric as being necessarily secured by a system of ties; and that it is not to be safely trusted to the independent spirit of its own construction. Assuming however this latter notion to be correct (as undoubtedly it is in theory), and that each particular ring of the dome is, by the goodness of the bond and the strength of the materials, strong enough to resist the pressure tending to burst it outwards, we might suppose that it would be self-dependent, and safe, without any extraneous guard of iron or other tie. But I apprehend that in practice this construction would be decidedly unsafe. Doubtless a vault of good brickwork laid in cement would be strong enough to resist any strain that the weight of a dome above could bring upon it, for we know its strength to be such that it is uncertain whether the bricks or the joints would break first, but in practice it is not safe to trust to this extent; strong as the work may be, the slightest yielding in the foundations will cause an unequal bearing in the weight above, and in a moment rend the strongest work. We may indeed imagine that a dome on a small scale may be formed of materials so strong and yet so light as to be effectively of one piece only, as though cut out of a solid block of stone, as is the Tomb of Theodoric, at Ravenna, or formed in one piece like a reversed cup; and in such a structure, no doubt, from the extreme tenuity yet strength of its substance, no ordinary rules for estimating the strength will apply.

Such also may be, and probably is, the case with such small semi-domes, for instance, as have been put up by my friend Mr. Scoles. One of them has a diameter of 30 feet, and is formed of four courses of plain tiles in cement, altogether 4½ inches thick. I believe that no failure has occurred in this kind of construction, which I have in my own practice also found to succeed very well. The strength in fact of this kind of work is so great, while its weight is so little, that it would perhaps render the fabric independent, to some extent, of a failure in the foundations, and unless it were heavily loaded in some particular part, would require scarcely any abutment or tie. Certainly this may and does suffice for small works; but if we extend the size we shall find the plan a somewhat dangerous one. We may strengthen the vault—put two feet of thickness where theory tells that one will suffice—and so trust our theoretically self-tied unbuttressed dome to stand as the great ones of old have stood. But in adding to its strength we

Digitized by Google

shall have doubled its weight; and should the carefully secured foundations yield only half a hair's breadth to this weight; should a little spring but carry away, gradually and unnoted, grain upon grain of the sand on which the massy piers of the dome may rest, soon will come the inevitable settlement, and our massive dome will rend and break away as though an earthquake had rocked it, and the more certainly in proportion to its very massiveness. Send but a single fracture through the thickness of the vault, and its self-tied structure is resolved into two or more separate parts; therefore, although I do not doubt that a dome may be made so strong and so compacted as to need no extraneous tie, yet the risk of fracture is so great that we ought not to depend upon the safety of such construction only, but insure for it such an abutment as may resist thrust, or such a tie as shall be free to some extent from the risk of fracture from the pressure of the mass above, in case a settlement should cause the latter to press unequally.

One instance, indeed, the well known one of St. Vitale, at Ravenna, exists, in which the construction is so arranged as apparently to provide against the necessity of any extraneous aid. The dome is formed of a triple coil of earthen jars, the end of each being socketted into the top of the one adjoining in a very ingenious way, so that it seems to me that if a settlement were to occur in the substructure, this peculiar arrangement would allow of a slight re-adjustment of the coils without destroying their connection. The only guard against the outward thrust is, so far as I am aware, the weight of the walls above the springing; and, altogether, this dome appears a very fine piece of construction, and worthy of a close and detailed investigation. In fact, I know of no other existing which combines all the qualities of strength, lightness, and flexibility, without the aid of any extraneous tie; but it has not to bear the great weight of the lantern which presses so heavily on the Florentine, Roman, and London dome; and I should hesitate to speak too confidently of its capacity to bear it, even if its outline were raised to that of a pointed arch.

Passing then this example by as one of doubtful authority, and looking only on the form of dome construction most usually adopted, and supposing its work to be good and solid, there will be little principle of the arch involved in its construction, whilst it might in fact be built up in a solid mass, like the arched rib made by the elder Brunel some years back, by building it out from each side of a pier so as to maintain the equilibrium of the two half arches. We know that he proceeded with the construction till each semi-arch overhung 60 feet, and if the corresponding half had been carried out, the two together would apparently have formed one arch of 120 feet span; in the same way that two raking pieces of timber would form an arch by abutting against each other.

Now, how should we break one of these curved ribs, assuming it to be secured at the bottom, and loaded at the top with the heavy weight of the lantern? I apprehend that it would snap at the lower part of the bend, and at that point therefore we should want the tie; if secured there, any weakness would be felt at an intermediate part of the curve. But supposing that instead of a curve beam we had an angular one, and that it was carefully secured at the angle, it is obvious that we should have the form of the Mansard roof alluded to by Dr. Robison; and I know of no power that could break it, short of actually crushing it. Now we have this condition actually fulfilled in the cone of St. Paul's, which, so long as the tie exists, may be considered indestructible; let us therefore take this as a starting point, and going one step further, suppose that Wren wished to make, as Brunelleschi did, the shell of the fabric form its outline, inside and out, instead of concealing it as in St. Paul's.

Add any form of curve we like, the cone itself would still remain as the great constructive skeleton, to which any superadded mass would serve only as a clothing I believe that this is the real secret of constructing domes whose size exceeds the safe limits of a brick or other beam, and that we ought to make such domes approach so closely to the conical form that their section should include that powerful outline within their thickness.

I do not say that a great dome cannot be safely erected with other outlines, because by careful attention to the goodness of the materials, and to the general bind of the work, it may, no doubt, be made secure. But I believe the form above mentioned to be the safest, and that any departure from it entails risk. To test the correctness of this opinion as far as possible, I have applied the form to the sections of the domes of the Pantheon, of St. Peter's, and of the Cathedral at Florence, with the following results:—In the Pantheon a cone of 2 feet thick (about 6 inches thicker than that of our St. Paul's), is contained in the curved surface from the horizontal line at top to the abutment. In the Florentine example a cone of much greater thickness is contained within the curved section from the foot of the lantern to the tie orignally inserted by Brunelleschi, and never added to since. In St. Peter's a cone of similar thickness is contained in the curved section from the bottom of the lantern to the tie last put in, since which time no other has been, I believe, required. The rule bears of course upon one particular class of domes, in which a top mass of great weight has to be borne independently of the fabric itself.

There are, however, other cases in which this conical form does not obtain; but in these, so far as I am aware, the weight of the lantern is wanting, so that the curve has only the weight of its own section to sustain. Such are the domes of St. Sophia at Constantinople, and the celebrated one at Beejapore. Having no personal knowledge of the Indian domes, I speak of this last example with much diffidence, but judging from Mr. Fergusson's excellent description, I should say that the enormous thickness of this well-compacted roof renders it, as it were, equivalent to being cut out of one solid stone. I am the more satisfied that this is a correct idea respecting these domes, because it is stated that in some of them, though the foundations have given way, the domes are left intact. I shall, however, assume it to be composed of somewhat inferior materials, so as to render the outline of consequence to ensure stability.

In these flat-topped domes we have to provide both against the weight of the mass and the extra weight after every snow storm; and although this is not likely to demand the precaution of the single cone, still the conic principle modified must, I think, be carried out; and we must provide against the strains as we should in a Mansard roof, by inserting a tie at the base of each cone (answering to the roof strut) varying in strength in proportion to the angle and the weight. But it is clear that there is a limit to the angle, beyond which it would not be practically safe to trust to the cone, and for reasons too long to mention, I think that 40 degrees with the horizon should be the limit. Beyond this upper cone there remains an almost horizontally flat portion (seen most clearly in the example at Beejapore) of such evident weakness, that Brunelleschi was of opinion that it could not be strengthened sufficiently to bear the weight of a lantern, and for this reason he gave his dome the section of a pointed arch. It is undoubtedly weak; and cannot be treated in the same way as the lower parts. Let us suppose a solid ring at the top of the cone, leaving an opening as at the Pantheon. So far it will be safe. We have now to fill in this space with brick or stone work capable of bearing the superincumbent weight; and this filling-in must, I think, be considered as a solid curved beam, cut out of a mass, and strutted well at the abutments, conditions requiring no great strength where there is no lantern.

In conclusion, I would briefly recapitulate my opinion respecting the construction of domes.

I consider that the essential element of strength in a dome is a straight cone (whether simple in one unbroken length, or compound in two or more lengths) comprised within the section of its vaulted covering. That the base of each cone must be securely tied. That although, for the same reason as in ordinary walling, we ought to secure by bonding and perfect bedding this vaulted covering in every part, yet, with good materials and work, these ties at the base of the cone are the only ones theoretically required. That the strength of such ties at any part is to be found by resolving the weight, by the ordinary resolution of forces, into the lateral pressure at that part. That in domes with heavy weights at the apex the straight cone is the only safe one to adopt. That the vault may be made strong enough by ribs alone, and that when these ribs are required not to project beyond the general face line, inside or outside, double vaulting as at Florence and at St. Peter's may be safely used, but only as a means of lightening the weight. That although, by goodness of the work, domes may be erected strong enough to bear any amount of weight without any extraneous tie, yet that such tie should be always inserted as though the ribs were quite separate, in order to guard against settlements. Lastly, that the thickness of dome will be sufficient if it include within its section a cone, necessary to bear the weight.

Though believing these views to be correct, it is with conside-

Digitized by Google

rable diffidence that I put them forward, as they are, I have reason to think, opposed to those entertained by some who are well qualified to form a judgment on the subject, which is indeed one not to be entered on lightly. No one can forget the sense of solemn awe with which he has viewed the gigantic vaults of which I have spoken: for my own part, when engaged in investigating the secret of their build, in laying bare as it were the skeletons of these great works, and touching at every turn the memorials of such men as Brunelleschi, Michael Angelo, and Wren, there arises with the ordinary methodical calculations respecting strength and materials a strange feeling of reverence for the works we have been examining, and of distrust of my own ability properly to comprehend them.

A NOTE ON THE BINOMIAL THEOREM.

By Arthur Cohen, B.A., Magd. Coll. Camb.

I assume that the Binomial Theorem has been proved for positive integer exponents, so that supposing m and n to be positive integers, we have

$$(1+x)^m = 1+mx+m\frac{m-1}{2}x^2+m\frac{(m-1)(m-2)}{2.3}x^3+\ldots \quad \ldots (1)$$

$$(1+x)^n = 1+nx+n\frac{n-1}{2}x^2+n\frac{(n-1)(n-2)}{2.3}x^3+\ldots \quad \ldots (2)$$

But $(1+x)^m.(1+x)^n=(1+x)^{m+n}$. Hence the product of the series which form the right-hand members of (1) and (2) must equal $(1+x)^{m+n}$; that is

$$\left.\begin{aligned} 1+(m+n)x+\frac{(m+n)(m+n-1)}{2}x^2+\frac{(m+n)(m+n-1)(m+n-2)}{2.3}x^3+\ldots \\ = (1+mx+m\frac{m-1}{2}x^2+\ldots)(1+nx+n\frac{n-1}{2}x^2+\ldots) \end{aligned}\right\} (3)$$

It is then usual to assume that the product of the two series which occur on the right-hand side of the last equation must be of the same form, whatever m and n may be.

That this assumption is unwarrantable may however be easily shown. Take for instance the expression

$$m\cos(2\pi m)\times n\cos(2\pi n)$$

This equals mn when m and n are integers, but *not* when m and n are fractional.

That however which one has no right thus to assume may be proved in the following manner:

It is an elementary proposition in the Theory of Equations, that if a rational integral function of the rth degree is equal to zero for more than r values of the variable, it is identically equal to zero. From this it follows that if two rational integral functions of m of the rth degree are equal to one another for more than r values of m, they are identically equal to one another.

Let then $f(m,n)$ and $\phi(m,n)$ be two integral rational functions of m and n of the rth degree with respect to m and of the rth degree with respect to n, and let $f(m,n)=\phi(m,n)$ for all integer values of m and n. It follows that the coefficients of the powers of m in $f(m,n)$ must be equal to the coefficients of the like powers of m in $\phi(m,n)$ for all integer values of n, and as those coefficients are rational integral functions of n, it follows that those respective coefficients must be identical with one another, and therefore that the two functions are identical with one another, and that they are equal to one another for *all* possible values of m and n.

Let us now apply the above to the product of the two series

$$1+mx+m\frac{m-1}{2}x^2+\ldots, \text{ and } 1+nx+n\frac{n-1}{2}x^2\ldots$$

The coefficient of x^r in the product will clearly be a rational and integral function of m and n of the rth degree with respect to m and to n. Since then such coefficient is for all integer values of m and n known to be equal to

$$\frac{(m+n)(m+n-1)\ldots\ldots(m+n-r+1)}{2\ldots\ldots r},$$

it follows that such coefficient is *identically* equal to the latter expression, and therefore equation (3) is identically true.

I have thus filled up the gap which is usually left in what is known by the name of Euler's Proof of the Binomial Theorem.

BREAKWATERS
AT
DOVER, ALDERNEY, PLYMOUTH, AND PORTLAND.*

(With Engravings.)

Breakwater structures have generally been divided into two classes; one known as the 'long slope' section, of which the Plymouth breakwater may be taken as an example; and the other, the 'vertical wall' section, of which form the new pier at Dover is an illustration; the works at Alderney, and the inner breakwater at Portland, being a combination of the two.

The Plymouth breakwater, as is well known, was of these the first in order of time; it consists of a large mass of stone, deposited on the site of the work and exposed to the action of the sea, which, after the occurrence of gales of wind, has caused the surface to assume a certain determinate form, as it always does under such circumstances. In the case of the Plymouth breakwater, an additional mass or foreshore has been placed on the seaward side, in order to diminish the force of the sea upon the inner or main work.

A breakwater of this sectional form is admissible only in those cases where stone is abundant, and where it can be procured in large sizes; the quantity requisite for a given length and depth of water being much greater than in any other section. It should be observed, moreover, that the amount of material required for a work of this description will depend in a very great degree upon the range of tide at the site where it may be adopted. This arises from the fact, that within the limits of the tidal range, the sea invariably disposes of the materials in the form of a long flat slope. In exposed situations this slope is seldom or never of a steeper inclination than five feet horizontal to one foot perpendicular, and sometimes even flatter than this. Under the level of low water spring tides there is also, under similar circumstances, a flat slope, having generally an inclination of about four or five to one, this extends from low water of lowest tides, down to about twelve or fifteen feet under that level; from this depth to the bottom,—however deep the water,—the inclination is of a much steeper character, varying but slightly from the angle which the same materials would assume if allowed to roll over a bank above water. This arrangement of the materials by the action of the sea is exemplified in the sections of Alderney, Plymouth, and Portland, and a similar state of things invariably occurs under analagous circumstances.

Although the sea face of the new work at Dover is not strictly vertical, the general character of the section is such that it may be regarded as an illustration of the vertical-wall system. In works of this class the quantity of material employed is assumed to be reduced to a minimum, in which respect they differ essentially from those on the long-slope system; the former has, consequently, been adopted in cases where there is a want of suitable materials in the locality, and the latter where stone of proper quality is abundant.

As we have stated the breakwater at Alderney, and the inner breakwater at Portland, are instances of the combination of the long-slope and vertical-wall systems. After the description we have just given of these systems, it would seem to be unnecessary to do more than refer to the cross-sections, an inspection of which will show all the essential features of the works which they represent (see Plate).

For many years a great difference of opinion existed among engineers and scientific men as to the relative advantages and disadvantages of the long-slope and vertical-wall systems, many authorities insisting upon the theory that in the case of a vertical wall rising from the bottom in deep water, the wave is a simple undulation, and that it would rise up against a vertical face and act by its statical pressure only; whereas in the case of the adoption of the long slope, the character of the wave would be so completely and entirely changed that it would have a considerable amount of progressive motion imparted to it, and consequently great percussive force, the result being that the whole weight of the mass of water multiplied by the velocity with which it was moving would be the measure of the force exerted on the slope.

On the other hand it has been urged by eminent men, that so far from the sloping form of breakwater creating the force with which the wave rushes up the slope, it is owing to this force of the wave being permitted to expend and exhaust itself that the effect upon the structure in a horizontal direction is diminished;

* From the Supplementary Report of the Harbours of Refuge Commissioners.

Digitized by Google

these authorities asserting that the same force will act wholly like a ram upon the perpendicular wall, tending thereby to overthrow it. Many arguments were advanced in support of these conflicting opinions, especially about the period of the inquiry by the commission on the proposed harbour of refuge in Dover bay, in 1845-6.

Having endeavoured to give as concisely as possible the principal arguments advanced in support of both systems by their respective advocates, we should state that our own views of the *theoretical* part of this subject are in accordance with the opinions of those who, like the majority of the commissioners of 1846, approve of the upright wall. We base our opinions upon the now generally admitted conclusion that even in the heaviest gales the disturbing effect of the wave is but very slight at comparatively small depths below the surface, and that the character of the wave in deep water is essentially different from that which it assumes when influenced by the friction which arises from the ground in shallow water. A valuable paper on the subject of waves, by Mr. J. Scott Russell, will be found in the report of the British Association for the Advancement of Science, for the year 1844. Among other results arrived at by the accurate experiments and observations of that gentleman, it was found that in comparatively deep water the waves are formed by a movement which is little more than a rising and falling of the particles near the surface, which surface '*oscillates* above and below the level of repose,' these are described as 'oscillating waves;' whilst in shallow depths the motion is onward and progressive, consisting of a 'translation of the whole mass of fluid from one place to another,' the waves in this case are called 'waves of translation;' one important law deduced from these observations being that as the waves approach the shore they begin to break whenever they reach a point where their height becomes about equal to the depth of the water in which they they are moving. The report states that 'at a great distance from the shore, or where the shores are deep and abrupt, a body floating near the surface is alternately carried forward and backward by the waves, neither is the water affected to a great depth; whereas nearer the shore the whole action of the wave is inward, and the force extends to the bottom of the water.'

Whilst these results are in accordance with general experience, it may be well to remark, that the height and character of the wave and the depth of water in which it will break are greatly influenced by the existence of a current or stream, whether tidal or otherwise, as observation and experience have shown that in those cases where there is a current or stream moving in *opposition to* the direction in which the waves are travelling, their height and force is greatly increased beyond what they would have been had no such current existed; whereas, in the case of a current moving *in the same direction* as the travel of the waves, their height and force is diminished. The character of the waves, and the depths in which they will break, will also be modified by any sudden or material changes in the depth of water, or in the form of the shores or the bed of a bay or channel in which they may be moving.

Those who have observed the waves on the coast in the English Channel or German Ocean, have described them as attaining varying heights, but there is a general agreement to the effect that the height ranges between 12 and 15 feet in heavy gales of wind. Observation has also shown that, as a general rule, the waves in heavy on-shore gales begin to assume a broken character, and to attain great force on reaching those points where the depth of water becomes reduced to about 2 or 3 fathoms, which depth would be about the height of the waves in such gales, thus confirming the conclusions arrived at from the observations and experiments already referred to.

Though the deductions from these careful experiments would appear to be confirmed by general observation, we have been led to the conclusions which we shall presently describe, almost entirely by the practical results exhibited at those breakwaters the substructures of which have been formed by a mass of rubble allowed to assume any form that may result from the action of the waves. It is remarkable and at the same time important to observe, that in all works of this class the seaward slope invariably assumes a distinct change of inclination at some comparatively small depth below low water; this depth being 15 feet at Alderney, 8 to 10 feet at Plymouth, and 12 feet at Portland; the same general result is found to exist at Holyhead, Kingstown, and Cherbourg, and considering the difference in the size and form of the materials employed, and the exposure of the different sites, the uniformity is striking. From these facts the conclusion becomes inevitable, that the scouring action of the heaviest waves will not extend below a depth of 12 to 15 feet in any ordinarliy exposed situation on our coast, or at any rate, that there will be no action sufficient to disturb the rough stone of the sizes usually employed in works of this description.

Having regard to these facts, we are of opinion that the section advisable to adopt in many cases will be that which consists of a base formed of rough stone of various sizes, rising from the bottom to the level of 12 or 15 feet under low water of spring tides, founding thereon a structure of masonry, with a vertical face on the seaward side, extending so far above high-water mark as may be considered advisable under the circumstances. This masonry need not extend through the whole breadth of the work, but may be backed up with rough rubble stone, in order to give sufficient weight to the structure, the face on the harbour side being finished in any manner that may be considered expedient, having reference to the requirements of each particular case. Although the first cost of a work in the form of a section here described may be somewhat greater than that of one in which the masonry is founded on a rubble mound at the level of low water, we conceive that it would be less exposed to damage from heavy seas, inasmuch as the base would not reach so near to the surface as to cause the waves to assume a forward or progressive motion, even in the heaviest gales, and the work would consequently not be exposed to the heavy impact due to waves of 'translation.'

It would manifestly be injudicious to attempt to devise any particular form of section which should be applicable to all cases; we therefore wish to direct attention to the opinion that the form just described is that which we believe to be advisable in the majority of instances; but not invariably so, inasmuch as the particular circumstances of each locality must always have an important bearing upon the decision in this respect. The entire absence of suitable materials in the vicinity of a selected site would probably render that form most eligible which should be strictly on the vertical-wall system, the masonry rising directly from the bottom. On the other hand, there may be cases with an abundance of stone in the immediate vicinity, well adapted for the formation of a rough rubble mound, but not suitable for masonry purposes.

At present there is an experiment being made at Portland, to which we think it necessary to refer. In the case of the outer or detached breakwater now in course of execution there, it has been found that the form of the rough rubble mound, after being exposed for a time and adjusted by the action of heavy seas, arrives at a state of rest, and the result of the experience of the last few years has been so satisfactory, that the construction of all masonry work upon the rubble substructure has been postponed, in the hope that any further disturbance of the materials will be so slight as to be practically of no moment, thus rendering a superstructure of masonry unnecessary, so far as its use as a simple breakwater is concerned; but upon the inner breakwater, which is connected with the shore, and will be used for the purpose of coaling steamers, the case is different, and accordingly a superstructure of masonry has been erected upon the rubble mound, as will be seen in the plate. The fixed character of the mound as it now stands in the outer breakwater, is owing to the supply of rough materials being maintained until the sea has formed the surface to the slopes indicated. Attention is also given to the admixture of the due proportion of several sizes of stone, in order to leave as little vacant space as possible. As a result arising from the rough character of the surface, the waves striking upon the seaward slope are broken up in detail, and there is consequently no body of water to recoil and disturb the stone when receding.

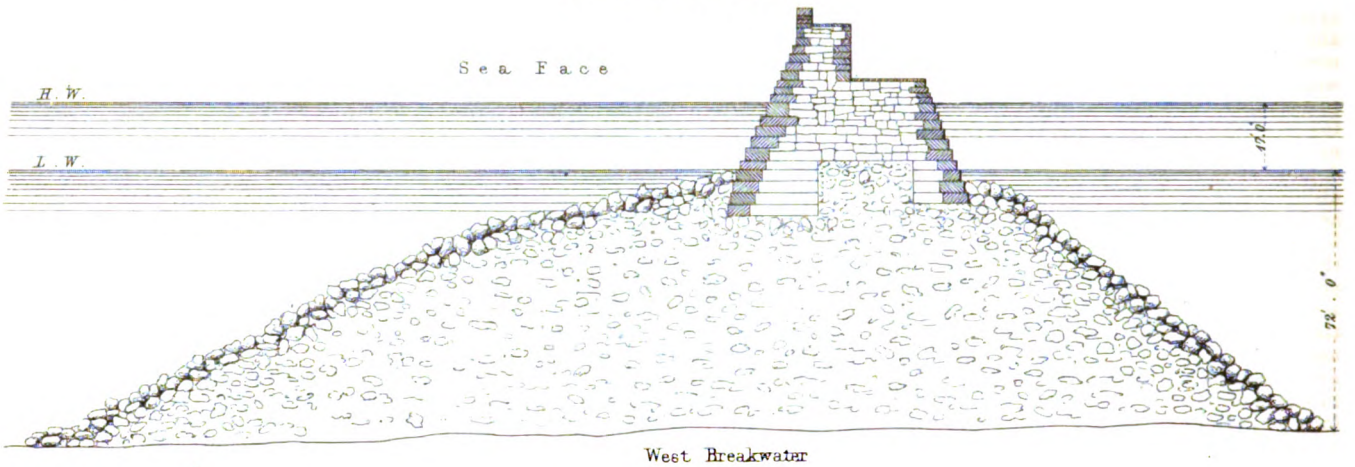
At the time when the vertical-wall was proposed for adoption, it was stated that any departure from the system previously resorted to would be 'a retrograde step in the path of science,' and it may possibly now be remarked that the formation of a breakwater by means of a simple mound of rubble, without masonry of any kind, is an unscientific mode of proceeding; but we conceive however that course of action to be preferable, and truly in the path of science, which effectually takes advantage of natural laws to accomplish the object in view, provided it be not attended with countervailing disadvantages. Should further experience confirm the success of the trial, it must necessarily have an important bearing upon the economy of works at those sites where the materials may be suitable and abundant.

Digitized by Google

Digitized by Google

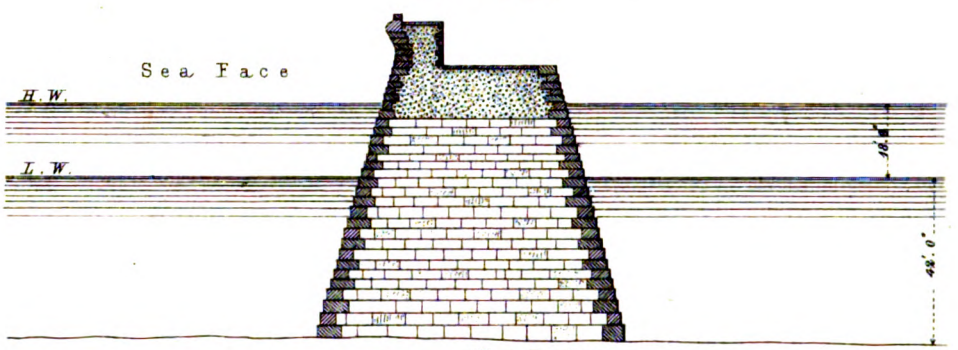
BREAKWATERS.

ALDERNEY.



West Breakwater

DOVER.

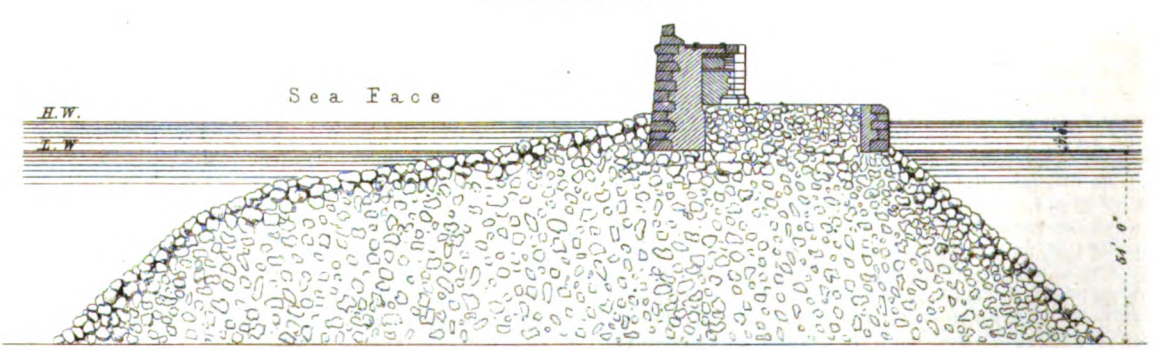


West Breakwater

PLYMOUTH.



PORTLAND.



Inner Breakwater

SCALE OF 0 10 20 30 40 50 100 150 200 FEET

July 1859

J.R.Jobbins

Digitized by Google

Modes of construction.—Proceeding to the different modes of construction in the order laid down, we have first the Plymouth breakwater. In this case the stone was taken in its rough state, and transported from the quarries to the site of the work by means of vessels built specially for the purpose. When the stone was deposited on the intended line of work, and the sea allowed to dispose of the materials, the result was the form indicated by the cross-section in the Plate, the only artificial aid to the determination of this particular form being the deposition of a considerable mass of stone, in the form of a benching or foreshore about 60 feet in breadth, which was added on the seaward side after the work had made considerable progress. The top, which is about 3 feet above the level of high water of spring tides, and the slopes both on the sea and harbour sides, were then pitched or paved with blocks of squared stone many tons in weight, and set on edge. In consequence of the scouring action arising from the recoil of the waves during heavy gales, the blocks immediately at the foot of the sea slope have been frequently undermined, and damage has arisen; to obviate this evil large squared blocks of granite set on horizontal beds, and dovetailed horizontally and vertically, are being introduced at the bottom of the slope, as indicated by dark shading on the section.

The new pier or breakwater at Dover is formed by an outer and inner wall built of ashlar masonry, with a course of granite on the face, and blocks of concrete made with Portland cement and shingle in the body or core of the work up to the level of high water, above which the hearting is filled in with liquid concrete. The masonry commences directly from the surface of the chalk which forms the bottom of the bay, the blocks being set below the water by means of diving apparatus. The sea and harbour faces of these walls are not strictly vertical, but have an inclination or batter in steps, of about three inches to the foot. On the sea side there is a parapet 15 feet above the level of high water, surmounted by a blocking course on the outside; towards the harbour there is a quay or roadway, about 30 feet wide and 10 feet above high water of ordinary spring tides. The whole of the operations necessary for setting the masonry are carried on from timber staging.

The breakwater at Alderney is formed by means of a bank of rubble stone, which is conveyed by means of a railway from the quarries about three miles distant, then loaded in hopper barges and discharged on the line of work until it reaches within 12 feet of low water; upon this bank a timber staging is erected, from which the masonry is set. The courses below low water on the sea face are of granite, and the backing of the walls of concrete blocks made with shingle and Portland cement, as in the case of Dover. The wall on the harbour face is composed entirely of concrete blocks below low water, and above that level both the sea and harbour walls are formed of large flat rubble masonry; the stone is quarried in the island, and the portion between high and low water is set in cement. At 6 feet above high water of spring tides, there is a platform or roadway of 25 feet in width. The seaward wall is carried 14 feet higher than this roadway, thus forming a protection against the sea in heavy gales; and this is surmounted by a parapet 4 feet in height. At the foot of the sea wall, rubble stone is deposited up to the level of low water of ordinary spring tides. All the operations requisite for completing that portion of the work above the level of 12 feet below low water, are performed from the timber staging before referred to.

The inner breakwater at Portland is formed by a rubble mound, composed of stone of all sizes, from 6 and 8 tons down to small chippings; and this mound is carried up to a few feet above the level of high water of spring tides. When it has been washed by heavy seas, a trench is excavated within the body of the mound to the level of low water of spring tides, and a wall of masonry erected. The face course is formed by large ashlar blocks, the body of the wall being of heavy rubble work set in mortar made of blue lias lime and pozzuolana. The ashlar face courses up to about 6 feet above high water are of granite, all the remainder of the stone employed being raised in the quarries in Portland. The sea wall is strengthened by counterforts placed 20 feet apart, and an arch being turned between each, a platform is obtained 15 feet wide, exclusive of footway and parapet. There will be a line of railway both on the upper and lower platforms, for the purpose of conveying coals and general stores to vessels of the navy that may lie alongside the jetties, one of which is now nearly completed. The whole of the operations at Portland are carried on from a timber staging, the rubble stone being conveyed in waggons drawn by locomotive engines, a mode introduced by the late Mr. Rendel, C.E., and in every way attended with success. It should be observed however that, guided by results obtained elsewhere, it was decided when the work was commenced to keep all the horizontal timbers of the staging not less than 12 feet above high water of the highest tides, and experience has shown that this is necessary to ensure safety.

NOTES AS TO THE CONSTRUCTION OF BREAKWATERS FOR HARBOURS OF REFUGE.*

By D. and T. Stevenson, Edinburgh.

The advocates of plumb walls for the seaward faces of breakwaters base their views on the assumption that all deep-water waves are pure waves of oscillation only, and have no percussive force. There is however no proof that purely oscillatory waves if opposed by a *continuous upright wall* exert only the hydrostatic pressure due to their height. Nor is it determined by actual observation that oscillatory waves, if reflected from the face of such a wall, may not cause succeeding waves in approaching the wall to break, at least partially, and thus to become to some extent waves of translation.

But even if it be admitted that purely oscillatory waves would not be found to exert percussive force, and that such waves would not be reflected so as to cause succeeding undulations to become waves of translation, the important question still remains to be answered—Are all deep-water waves really simple waves of oscillation?

During a perfect calm pure oscillatory waves no doubt traverse the ocean, but a gale of wind or a rapid tideway produces an entire change in their condition. All waves such as we are speaking of, owe their existence solely to the wind. Its action on the surface of the sea is such as to cause the water to rise in the form of a wave, the height of which depends on the amount of force exerted by the wind, and the time during which that force continues to act. When the wind ceases the waves are influenced only by the action of gravity, and become purely oscillatory waves; but so long as they are urged on by a heavy gale their symmetrical shape as undulatory waves, it is believed, cannot be maintained; and being impelled by the continued action of the wind on their windward side, the equilibrium is ultimately destroyed, and the upper part of the wave, urged on by this extraneous force, tumbles over and becomes a wave of translation. Were it possible to oppose a sloping face or a plumb wall to such a wave in the middle of the ocean we should unquestionably have the phenomena due to a wave breaking on such an obstruction. When waves break in the ocean, however, they are unobstructed by any fixed object, and are spent in plunging into the medium of which they themselves are composed, and are thus as it were swallowed up and lost to external observation. But still, even in the middle of the Atlantic the breaking wave is an invariable accompaniment of a storm, and from the great distance at which such breaking waves may be descried, and from their formidable appearance when breaking near a ship's course, and also from the actual damage which they have been known to do to the *windward* bulwarks of vessels, we are led irresistibly to the conclusion that the phenomenon is something more than mere superficial disturbance, and is in fact, as has been stated, a truly breaking wave. Again, in great storms it is admitted that waves break long before they reach the shore, in consequence, (as explained by the advocates of the purely oscillatory character of oceanic waves) of the depth of water being too small to admit of their propagation, and it has been variously stated by different authorities that from this cause waves break in water of from 5 to 7 fathoms in depth.

Harbour works are not likely in almost any case to extend beyond the 6 or 7 fathoms line, and from what has been said as to the effect of wind and shoal water in causing the sea to break, the three following inferences seem clearly to follow:—

1. That all harbour works, whatever be their form, or in whatever depth of water they may be placed, will be exposed during storms to those partial waves of translation which are due to the action of the wind.
2. That all such parts of these works as are in water of less depth than from 5 to 7 fathoms will be further exposed

* Originally addressed by request to the Royal Commissioners on Harbours of Refuge, and now communicated to this Journal by the authors.

Digitized by Google

to waves of translation due to the shallowness of the water.

3. That it is incorrect to assume that the works of harbours of refuge are never to be exposed to any greater force than that which is due to the pressure of purely oscillatory waves.

Assuming then that our sea works, whatever be the depth of water in which they are placed or the form or profile which they present to the sea, will necessarily be assailed by some kind of breaking wave, though we do not pretend to define to what order of waves they belong; the next question to be determined is the construction of breakwater which is best fitted to resist their action.

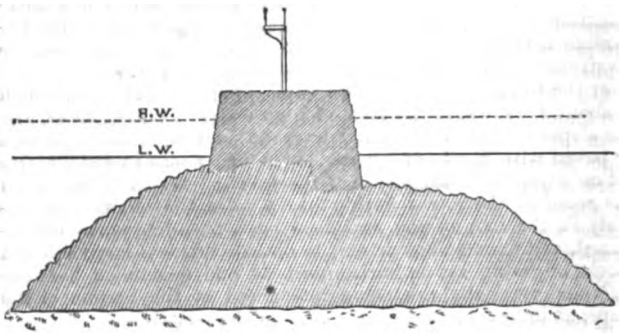
Perhaps we may assume it to be generally admitted that a *breaking* wave impinging on an upright wall rises higher and gives the resisting structure a greater shock than would result from the same wave impinging on a sloping talus wall. At North Unst, in Shetland, the sea rises on a nearly perpendicular face upwards of 200 feet, and at Barrahead, in the Hebrides, the waves rise still higher. Every one, indeed, who has watched the effect produced when a breaking wave impinges on sloping and on plumb walls which closely adjoin each other (which we have had many opportunities of doing) must have satisfied himself that while the sea rises and falls gently on the sloping surface, it strikes the nearly perpendicular face with great force, producing a loud report and raising the spray 30, 40, or 50 feet into the air.

In considering this result and others that have been noted, we are led to the conclusion that in designing works to withstand the sea the great aim of the engineer should be to resist or oppose the progress of the wave as little as possible. It is practicable to *direct*, but certainly not altogether to *check* or *control* the action of the sea by artificial works. This is well illustrated in practice by the difficulty which invariably occurs in forming a junction between a sea-wall and a projecting rock. If the projection arrests the progress of the wave suddenly the artificial work at the point of junction is certain to be very severely tried. For the same reason, in situations where the sea is confined between elevated rocks, it is believed to be in some cases all but impossible with ordinary materials to construct artificial works of sufficient strength to withstand its fury. Hence it is believed that horizontal projections in works which are intended to withstand the sea are not good in principle, as they tend to shake and try the masonry. It is safer engineering to allow the sea to expend itself in rising up perpendicularly in the form of spray or in flowing over the work in a sheet of water, than to attempt abruptly to resist its action.

These considerations seem to lead clearly to the inference that the most suitable form for the sea-face of a breakwater is that of a sloping talus wall, and, were it not for the great difficulty of founding and afterwards preserving in security the foundation of a sloping wall, and the great mass of material required in the construction of a breakwater designed on that principle, it would be a matter of prudence to adopt it. The disadvantages we have just noticed however are, we think, so great as to warrant the engineer to abandon that principle of construction for deep-water harbours of refuge. The plumb wall on the other hand, if brought up from the bottom, secures a comparatively small consumption of material, but the expense and the difficulty of founding such a wall in deep water in the open sea is a most serious drawback; and even if such a wall may, after its completion, possess all the advantages claimed for it by its supporters, still it must be remembered that these advantages cannot, as first suggested by Mr. T. Stevenson, be available so long as it is *in progress of construction*. All engineers will agree that the greatest risk which seaworks undergo occurs during their construction. If the process of building has been completed there is very little fear of the work in its finished state being destroyed. But during the critical period when the work is in course of execution both the facework and hearting are left open and unfinished, and the adoption of a plumb wall can be attended with no benefit whatever based on the assumption either that deep-water waves are oscillatory or that they will not become waves of translation if opposed by a plumb face. For it is well known as a matter of fact that the seaward end of such a wall while in progress is not, and never can be plumb, but consists of a succession of steps formed by the unfinished courses of masonry, which must necessarily be left projecting as the work proceeds. On this sloping end the sea during the whole progress of the work makes a clear breach, and the wall, even if executed on the plumb principle, is, along with the interior or backing, exposed to *breaking waves* during the whole period of the execution.

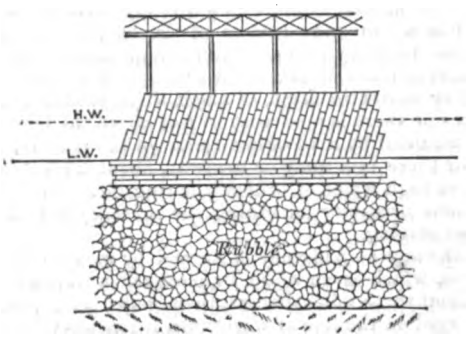
Holding these views we have been led, after much consideration, to recommend the form of structure shown in the sections of the proposed breakwater which have been submitted to the commissioners, a form which we originally suggested in 1856, when

Fig. 1.



designing the Refuge Harbour which was at that time proposed to be erected in Wick Bay by the British Fishery Society. Fig. 1 is a cross section, and Fig. 2 is an elevation of the sea face of the breakwater.

Fig. 2.



The profile of this breakwater, which may be regarded as a combination of flat slops and nearly plumb faces, possesses the following advantages, which our experience leads us to believe are worthy of consideration:—

1st. The underpart of the breakwater is formed of rubble which, when dropped into the sea from a staging, as has been so successfully used at Holyhead, by Mr. Rendel, adapts itself to the varying form of the bottom, and, when it consists of sand or other soft matters, the rubble sinks into it and forms a sufficiently wide spreading and safe foundation on which to erect upper works.

2nd. This rubble work is not carried above the height at which the larger sizes of stones are found to be moved by the action of the sea, a height which varies with the exposure from the low-water level to 12 or 15 feet below it.

3rd. The saving in cost in bringing up the lower part of the work by depositing rubble is, in most cases, beyond dispute. The uncertainty of founding an ashlar wall on a soft or uneven bottom in the open sea at a depth of 5 or 6 fathoms is, as has been already stated, a great objection to the system of bringing up the walls plumb from the foundation; while any settlement in the lower courses is likely to occasion the total destruction of the upper works. When rubble suitable for such a work can be obtained at a convenient distance, we therefore think that there cannot be any doubt as to the propriety of forming the deep-water part of the work with that material.

4th. The use of unprotected rubble however cannot, except in some cases, be advantageously adopted above low-water mark; while in other situations it cannot even be carried so high, for the action of the sea scatters the rubble, especially above the level of low-water. This difficulty has been found to be very inconvenient at Kingstown, and other works of similar construction, where the rubble was carried out with a high face and tipped over in the same way as practised in forming a railway embankment. This mode of construction exposes a large mass of stones above low-water to the action of the waves, which scatters them and greatly increases the mass of material required to form the breakwater.

Digitized by Google

5th. In order to obviate this difficulty the construction we recommend for the upper work is a rough but very strong wall, founded on the rubble, and composed mainly of stones set on edge. For that system of building we believe the profile shown on the section will be found to be best suited, but we are not prepared to say that more batter may not advantageously be given to the walls and a certain amount of convexity to the top. As the cubic contents of this superstructure bear but a small proportion to the mass of the breakwater itself, great facilities are presented for selecting suitable materials for its construction whilst quarrying the rubble for the under-water work.

6th. The vulnerable part of any sea-wall founded on rubble is the foundation, because the rubble stones are liable to be washed from the toe or foot of the wall. If the wall be surmounted by a high parapet this action of the sea on the lower portions of the work is greatly increased, whether the face of the wall be plumb or slightly inclined; and in order to modify the effect of that action we propose to dispense with a parapet on the proposed breakwater, and to allow the sea to pass freely over it. In this way we believe that the foundation of the outer or sea wall will be much less severely tried, and that the chances of its security will be greatly increased. As a proof of this particular action of the sea on a pier without a parapet, we would cite the results of some careful observations made by us at a harbour where a breach had been made in the parapet of the sea-wall, whose direction was parallel to that of the wave, and which was moreover exposed to a very heavy sea. On a wave approaching the pier, it struck the part which had not been damaged, and rose to the height of 30, 40, and even 50 feet above the parapet (which was 22 feet above high water); while that section of the wave which faced or was opposite to the breach, flowing freely over the pier, fell into the harbour without producing almost any commotion in the basin. While this comparatively peaceful flow of the water over the pier was going on, the other part of the structure with the high parapet was exposed to an intense force, and the foundation was of course subjected to a correspondingly great reaction. That portion of the facework opposite to the breach which was not destroyed had a curved batter increasing towards the foundation, where it was about 1 to 1. This work was superseded by a new wall with a straight batter of 2 inches to the foot, or nearly plumb, and the same action which we have described was observed on the new work while it was in progress,—the sea rising in masses above the finished parapet, and flowing over the unfinished or low part of the nearly plumb wall.

7th. The observations made at the place in question, and others of a similar kind which we have made elsewhere, lead us to the conclusion that while high parapets in very exposed places certainly do not render the roadway of the pier safe in heavy storms (when communication is often most needed), they tend greatly to aggravate the shock of the sea on the face-work and foundations, and increase the recoil of the wave, the work is further endangered by the falling of heavy masses of water on the roadway from heights varying, according to our own observation, from 20 to 70 feet. It therefore seems to us to be very questionable in how far it is consistent with sound engineering to erect a high parapet at a heavy cost on a breakwater which is not intended to serve as a commercial pier, but is designed only to protect vessels lying under its lee.

8th. To secure access along breakwaters without parapets such as we recommend, we propose to have a raised gangway supported on some of the staging-piles which will be left in their places for that purpose. The solid water, as in the case of the breached pier already alluded to, will pass comparatively gently *over* the surface of the breakwater and *under* the platform, which will only be exposed to spray caused by the striking of the waves against the comparatively low plumb face of the pier, chiefly at or about the period of low-water. We believe that there will not, excepting in very peculiar circumstances, be any danger in passing along such a stage; and it is confidently anticipated that a passage may be comfortably effected along a stage so constructed in states of the sea when the roadway of a pier would be altogether impassable even if it were protected by a high parapet.

9th. No objection can be raised as to the stability of such a staging. Abundant proofs can be given where isolated piling, in consequence of the sea getting free access round it, has stood perfectly secure, when large stones built into a wall alongside of it have been carried away, simply because the progress of the wave was opposed by the continuous wall.

The peculiarities of the form of breakwater which we have recommended may be stated shortly as follows:—

1. Advantage is taken of the non-moving power of the sea at low levels to employ for the under-water work rubble, which is a comparatively cheap material.
2. This arrangement secures a perfect adaptation of the foundation of the structure to the bottom, however soft or uneven.
3. On the rubble so deposited a superstructure is raised, composed of materials arranged on edge, and protected where necessary by such a system of iron strapping as shall eminently qualify it for withstanding the sea during its erection.
4. The stability of the work is further provided for by having no parapet, and thus the force of the waves on the sea face, and especially on the foundations, will be reduced, while the fall of masses of water from a great height on the pitching is prevented.
5. Communication is obtained by an elevated gangway supported on piles and raised above the passing seas.
6. The proportion of the expensive ashlar work forming the superstructure is very small as compared with the whole mass of material.
7. For breakwaters intended merely to shelter vessels, no parapet is required; and in situations where such breakwaters are likely to be erected, no parapet could during bad weather render the piers suitable either as berthage for vessels to lie alongside, or as roadways for safe communication.
8. The form of breakwater proposed therefore combines efficiency with economy.

THE LATE CHEVALIER MONTFERRAND.

Monsieur de Montferrand is among the remarkable architects of the present century—remarkable for the position he occupied in one of the leading European capitals, for the important monuments he erected, and for his great personal success. He was a Frenchman by birth, having been born at Chaillot on the 24th January, 1786, and was a scholar in the fertile classes of Percier and Fontaine, at Paris, from which proceeded so many men eminent in the art; and whose taste, as teachers, had so great an influence upon the monuments of Continental Europe of the first quarter of the present century. It is difficult to state precisely the causes which led to the predominence which Percier and Fontaine exercised upon the rising youth of the French school of architecture. Much arose from their releasing students from the thraldom of the vicious taste of the Louis XV. period: and much was due to the personal qualities of the former of these distinguished men, whose mastery of the pencil and enlarged views of Classic art no doubt gave him great weight. But the rigid laws of the Classic canons had to yield after his decease to those ideas of individual freedom of thought which have since enlarged the sphere in which the imagination of the rising generation has allowed itself to wander. De Montferrand appears to have been engaged upon the works of the edifice which subsequently became the Eglise de la Madeleine, and which from the time of Louis XV. had undergone various transformations in its conception and decoration. In the German wars, which concluded the career of Napoleon I. we find him in the army, which he quitted at the restoration. For such a spirit Bourbon France offered no chance of success, and after studying in Rome for a short time, where Dupaty, Milhomme, Calamar, Granet, Chauvin, Nepveu and others were his comrades, he sought in Russia a field of enterprise for his talents, where from the paucity of able architects he soon found employment, and constructed the Palace of the Prince Labanoff. In 1817 his design was successful in a competition for the new church of St. Isaac, which was intended to supersede the older fabric, and to vie, as the Cathedral of the Russian Empire, with the others of Christian Europe; and which was not completed till forty years afterwards. With unlimited funds at his disposal, the choice of the materials left to his discretion, and with no restrictions in any respect, the church of St. Isaac, though gigantic in its proportions and profuse in its decoration, falls short of its object and does not fill the eye nor satisfy the taste. In 1829 he was charged by the Emperor Nicholas to erect a column commemorative of his brother Alexander, without any reserve as to cost. De Montferrand wisely determined that this project should bear comparison with the monuments of ancient

Digitized by Google

art in the choice of the material and the colossal scale of its monolith. The shaft consists of a single block of Finnish granite from Pytterlaxen, 11 ft. 6 in. diameter and 84 ft. high, and is of Roman Doric proportions with appropriate pedestal, base and capital, surmounted by a pedestal and a bronze statue of Religion. It is necessary to read his volume on this work, which shows the difficulties he had to overcome, and the rude workmen he had to educate in order to carry out his noble idea. This colossal columnar memorial is one of the most striking features of the Northern Metropolis of Russia. His last public work was the pedestal for the equestrian statue of the late Emperor Nicholas, consisting of enormous blocks of porphyry and bronze sculptures, surmounted by the colossal figure of the Emperor on his war charger, and which was intended to excel in scale and execution that of Frederick the Great at Berlin. But here was wanting the genius of a Rauch to give the impress of that elevation of sentiment and originality of conception and treatment, which render the monument of the Prussian king the finest example of modern monumental sculpture. This was his favourite, as well as the last work of his artistic career, with which Montferrand closed a practice of about forty years in St. Petersburgh.

He deceased in June 1858. The Chevalier had a great love for art, and collected a museum, which with patriotic zeal he wished to see placed in one of the towns of his native country, like the Wicar collection at Lille. This is a noble instance of the public spirit of an artist, anxious to endow the soil of his birth with a memento that should serve to promote the love and study of a pursuit, in which he had himself been distinguished. He published two noble volumes, illustrating the Cathedral of St. Isaac and the Alexandrine Column.

HOUSES IN RELATION TO HEALTH.*

By Robert Druitt.

The speaker having alluded to the sickness, bereavement, and ruinous expense which sometimes ensue from the wrong choice of houses by private individuals, and to the disorders liable to be diffused amongst all classes from the unhealthy dwellings of the poor, proceeded to consider the subject of houses and their influence on health under three heads. Under the first he treated of deficiencies of air, light, warmth, and dryness, and of the maladies of degeneration to which they give rise, of which consumption and scrofula are types; under the second he spoke of the common typhoid fever of this country, and of choleraic disorders, and of their origin in defective house-drainage; and under the third he discussed the conditions which give intensity and power of propagation to certain diseases, such as scarlatina and diptherite.

Amongst the details noticed under the first head, he observed that the ground on which a house is built should have the qualities of porosity and firmness; porosity is required in order that all water charged with organic debris which happens to penetrate it, may pass onwards and undergo that rapid oxidation which is so happily effected by the London gravel. Wherever the soil is deficient in this quality, or where beds of gravel or sand come in contact with beds of clay, a thorough subsoil drainage is as essential for the health of man, as it is for the growth of sweet herbage. Spots can be pointed out in which the subsoil is swampy, and where fever has prevailed in consequence. Moreover, the land on which houses are being built around London is sometimes raised artificially by what is called made-earth; that is to say, on a low wet spot quite undrained are heaped all sorts of rubbish, road scrapings, mud, and refuse, mixed with organic debris; and over this the houses are built. Besides, the excavation of sweet wholesome gravel, and the filling in the vacuity with rubbish, has long been prevalent at the west of London, and was much to be condemned; and an instance was quoted of a house, whose rental was 400*l.* per annum, built over a laystall of the last century, that is a pit where every kind of impurity was deposited, and now filled with black mould mixed with sheep bones. This earth, when dried and analysed, yielded 10 per cent. of organic matter, and was as unwholesome to build on as an old churchyard.

Want of firmness might be remedied by a solid floor of concrete, after the Roman manner, which would enable houses to be built with less chance of settlements and cracks, which are causes of unhealthiness, not merely by allowing cold and damp to enter, but by permitting currents of fœtid air to come from unknown and distant sources. Thin walls, too, render a house not only extremely cold, but unwarmable in winter.

Passing over the grouping and position of houses, and the width of streets, which ought to be regulated by the height of the sun in winter, we come to the internal arrangements and air supply. The last may be provided by some special ventilating apparatus, or may be left to take care of itself: but even if left to itself, it will be prudent to see that the basement doors, and other chief apertures, are not near any source of contamination; moreover, great caution should be exercised in roofing in yards and areas with glass, as is often done, because the glass may cover over some sources of effluvia, and bring them into the house. This has been the cause of fever.

The supply of air to the apartments should be large, diffused, and not in perceptible draughts, and warmed, and should be so contrived as not to attract attention: otherwise persons who are afraid of pure air, especially servants and the poor, will speedily close up the apertures. The plan suggested by the Commissioners on Warming and Ventilation was exhibited, and described as fulfilling most of these conditions—inasmuch as the air is warmed by the heat otherwise wasted by the chimney, and is introduced in ascending currents; and care is taken that there is a channel of escape separate from the chimney, and that the upper part of the apartments should be the coolest. Any plan for bringing currents of cold air to the level of the feet, or of the bed, is to be condemned. Nothing can be a better evidence of the carelessness of our present system of air supply to houses, than the fact that much of it comes down the chimneys when there is no fire, bringing with it abundance of soot, and many, possibly unwholesome, products of imperfect combustion of organic matter. A free supply of pure air is the *sine qua non* to persons who lead in-door lives.

Further researches on the composition of house air are to be desired. It is evident that the amount of carbonic acid represents that of the most volatile, and probably that of the most innoxious product of the presence of living beings, and consequently the *minimum* of atmospheric impurity. The speaker had made several determinations which showed how rapidly the quantity fluctuated according to the amount of ventilation and the state of the wind. For example, in a small room in May's-buildings, Brick-street, inhabited by two adults and three children:—

	Volumes of Carbonic Acid in 10,000 vols. of air.
April 20th. Noon; family dining	13·74
„ 21st. „ „ „	9·19
„ 24th. Room empty, door open	3·34
„ 20th. All night	15·97
„ 21st. „	15·10
„ 22nd. „	12·27
In the Infant school-room, Curzon schools, Mayfair, room crowded, with a window open at each end	9·46

In a bed-room, unoccupied, but with the doors and windows closed all day, the quantity fluctuated between 5 and 7 volumes per 10,000.

The list of maladies arising from cold, damp, airless, and sunless dwellings, is a long one, and is identical with the maladies caused by hunger, depraved nutrition, solitude, and grief; moreover, the effects of dark, monotonous and decayed dwellings upon the mind must not be overlooked, inasmuch as they produce a direct temptation to indulge in spirituous liquors.

Under the second head the speaker alluded to the great number of modes in which a house may receive poisonous vapours from sewers. If the house drainage has not been revised during the last ten years, there may probably be every variety of imperfect and dilapidated drainage; wells that once supplied a family with water may have been converted into dead wells and receptacles of filth; and even when a house possesses a perfect drainage system of its own, it may be invaded by its neighbours; or the remains of old drainage systems may have been left by the carelessness or ignorance of workmen. Every pipe too, of whatever sort, may be a means of bringing foul air from sewers; every such apparatus should therefore be examined from time to time, and be regulated with philosophical precision. The possibilities were described of the entrance of air from the public sewers into houses, either from stagnation and decomposition, or through the wind which at certain times penetrates the great sewers from the river; then, wherever a sewer ends abruptly, the gases are sure to be driven out of it, through the apertures in the streets made for ventilating purposes.

* From a paper read at the Royal Institution.

Digitized by Google

The effects of back house drainage, and of sewer poison, are found in the prevalence of typhoid fever and choleraic maladies. The great fevers at Clapham, Croydon, Westminster, and Windsor, were all of this sort, and traceable to this cause; and instances were given of illness, year after year, visiting a family, and robbing it of one or more lives; and when too late, the discovery made that an ancient, unknown, and decayed sewer ran under the premises. Many such sewers exist underground, not noticed in any map, and unknown to the present generation of officials; serving only as reservoirs of foul gases, which find vent through most unexpected channels.

It is in vain for the physician to discuss remedies whilst the patient is still breathing the vapours which caused the disease.

Lastly, the property which the diseases have of lurking in certain quarters, and then breaking out with virulence, and acquiring a self-propagating force, was ascribed to impurity in general, and to defective drainage in particular. Scarlet fever, especially, was asserted by the speaker to be caused *ab initio*, as well as to receive power of extension from this source. Thirteen contagious maladies, at the least, can be produced at will; and the speaker believed that in time epidemic diseases would be found subject to human control; and that the surest mode of protecting the dwellings of the rich was to cleanse and ventilate the dwellings of the poor.

Diagrams were exhibited, showing the mortality in several parts of the parish of St. George, Hanover-square, by which it appeared that, out of 20,000 inhabitants of first and second class streets there died at *home*, in the three years 1856, 1857, and 1858, 10·78 per thousand per annum; whilst, in third and fourth class streets, there died at *home* in those three years 20 per thousand per annum, exclusive of deaths in hospitals and workhouses. Taking the *mews* separately there died at *home* 15·36 per thousand per annum.

The mortality and population of several streets during these years were also exhibited in a diagram, which contrasted the low mortality of purely aristocratic and first-class business streets with that of the nest of low streets between Grosvenor-square and Oxford-street, where, owing to the crowded and unventilatable state of the houses, there is a mortality of 30 per thousand,—a mortality enhanced, of course, by the deaths of the children who are born but cannot be reared in such habitations.

ON THE ORDNANCE SURVEY.*

By Colonel James, R.E., F.R.S.

I am afraid you will find this a very dry subject, but I will endeavour to go rapidly over the various points, more with the view of giving a correct outline of the whole proceedings and history of the Survey, than of going into minute details, which would be more adapted for a book than a lecture.

The history of our Survey presents a most remarkable example of that gradual and slow development of just views which we often witness on other questions in this country; and as there has been so much discussion, and so many changes in the orders which have been issued from time to time respecting it, I have gladly availed myself of this opportunity to explain to the officers of the army and navy, and the public generally, the exact state of the question at the present moment.

The survey commenced under General Roy, R.E., in 1785; but the object then in view was simply the production of a military map on a 1-inch scale, and that survey, with considerable interruption, consequent upon the wars then going on, had extended in 1824 from the Land's End to the boundary of Yorkshire and Lancashire, including the whole of Wales. It was then decided that there should be a general valuation of Ireland, and that, as a necessary basis for that valuation, there should be a townland survey; Ireland being divided into smaller divisions of parishes than England, called townlands, which are generally co-extensive with private properties, averaging about 300 acres each.

The whole survey force was then sent to Ireland, and the survey of Great Britain was altogether suspended. We commenced first in the North of Ireland, I myself taking part in the survey. To obtain accurately the acreage of the townlands, which was at first supposed to be all that would be required, it was decided that the scale should be six inches to the mile; and then commenced that series of mistakes which has interfered with our proceedings up to the present day. For no sooner had we completed the survey of four counties, according to our instructions, than it was found that the skeleton plan, containing the mere boundary of the townlands and the principal roads and rivers, was altogether insufficient; and that every field and garden must be surveyed to enable the tenement valuation to be made. We had consequently again to proceed to the North and complete the survey, and we have hardly completed it yet, having to put in every single field through the northern counties of Ireland. Our parties are now finishing it—they are in Armagh, and have nearly completed that county; and, when that is finished, I trust it will close the six-inch survey of Ireland. But the mistake and its consequences do not end there. Under the newly-constituted court, which was called the Encumbered Estates Court, and which is now called the Landed Estates Court, a vast amount of property is being constantly sold; and for the purpose of sale they require accurate plans of the property. When you bear in mind that on the six-inch scale sixteen acres occupy one square inch only, you will understand how inadequately represented upon that scale were the small sub-divisions of property. By a curious coincidence just as a royal commission on the survey had recommended the 25-inch scale for the survey of Great Britain, the judges of the Landed Estates Court in Ireland made an application, which has received the sanction of the Treasury, for the introduction of the 25-inch scale for Ireland, for the plans of all estates sold under the Landed Estates Court.
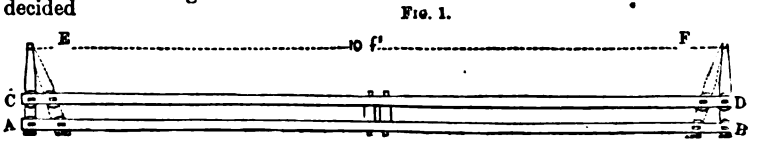
The survey of Ireland was completed on the six-inch scale; and, although it is to be regretted that it was not made in the first instance on a much larger scale, still it was found to be of such immense benefit as compared with the one-inch, that, when we resumed the survey of Great Britain in the North of England and South of Scotland, we were ordered to proceed upon the six-inch scale, as we had done in Ireland; and we completed the whole of Yorkshire and Lancashire, and several small counties on the South of Scotland on that scale. After we had completed Yorkshire and Lancashire, and several of the counties in Scotland, there commenced a discussion upon what was the proper scale for the plans, which, if it is quite closed, has only just been brought to a close; a royal commission, composed of many of the most distinguished men of the day, of which Lord Wrottesley, president of the Royal Society, was chairman, having unanimously recommended the adoption of the 25-inch scale as the national scale for our cadastral survey.

With these preliminary observations, I may proceed to describe the operations of the survey itself. The first requisite for a survey is, of course, a triangulation. When I say a survey, I speak of the survey of a great kingdom, not of a limited district. It is absolutely necessary that you should have an accurate triangulation. And, as a preliminary to obtaining an accurate triangulation, you must have accurate bases measured.

The bases that have been measured, and from which all the distances in that triangulation have been computed, were those on Salisbury Plain, at Lough Foyle in Ireland, Misterton Car in Nottinghamshire, Rhuddlan Marsh in the North of Wales, and Belhelvie in Aberdeenshire. The two first were measured with Colby's compensation bars, the others with steel chains 100 feet long (Fig. 1).

The compensation bars for the measurement of bases, which were designed by the late General Colby, are made in this way: a bar of brass, AB, is firmly connected to an iron bar, CD, at their centres; these are again connected at each end with two iron tongues, EA, FB, moveable on pivots. On the projecting portions at EF a fine dot is made on a piece of platinum, and it is so arranged that the distance from the dot to the centre of the

Fig. 1.



pivot at C, shall be to the distance of the same dot to the centre of the pivot at A in the ratio of the expansion or contraction of the iron bar CD to the expansion or contraction of the brass bar AB. By this arrangement it will be seen that the distance between the dots at E and F remain at the uniform distance of 10 feet under every change of temperature.

These bars, in the actual measurement of the bases are laid perfectly horizontal by means of levels, and ranged in a perfectly

* From the 'Journal of the United Service Institution.'

Digitized by Google

The one suggested by the committee, which has not the testimony of any eminent engineer in its favour, together with many others, have been fully investigated; its action, however, is admitted to be imperfect, and this is probably the reason why it has not been preferred to others.

Superheated Steam.

Steam, as generated from the boiler, whatever be its temperature, contains such a quantity of moisture as makes it act in some measure as a lubricator to the cylinder. If, however, the steam were sufficiently superheated apart from the water, so as materially to increase its elasticity, the consequence of its drying qualities upon the working parts in the cylinder would be such as to cause either leakage or much friction. From this it may be deducible that the superheating of steam out of contact with water can only be beneficially employed for the evaporisation of any priming water carried out of the boiler by the steam pipe.

From what has been here stated, the reasons may be explained why the experiments made on superheating steam have given such different results. When the boilers were indifferent, and there was much priming water to evaporate, the gain from using this process appeared large; with good boilers, on the other hand, the gain appeared small.

If it is desired to secure to the navy the advantages of the process of drying the steam, the committee would recommend an addition to the steam space to be made round the uptake of the funnel.

Surveyor's Reply.

For many years all doubt has vanished respecting the fact that considerable economy arises from the use of superheated steam,—the degree of economy depending, as might be expected, upon the extent to which the principle is carried out, and upon the mode adopted for superheating the steam.

But the late Dr. Haycraft's experiments, and others, as well as those recently made in the Black Eagle, and now being continued in the Dee, prove incontestably the fact of economy, which generally, at a moderate estimate, may be taken at about 20 per cent.

The main points yet to be satisfactorily determined are—1st. Will no mischief be done, or greatly increased wear occasioned to the working parts of the engines in contact with this kind of steam at a high temperature; and whether, without greater care and attention than can be insured, is serious damage to the machinery likely to happen occasionally? 2nd. What is the most practical mode of carrying the principle into effective operation?

The subject cannot now be lost sight of, or fail to be prosecuted with assiduity. All persons interested in steam matters are fully alive to its importance, and well acquainted with what is being done.

On the Amount of Steam Power that can with most Advantage be placed on board Men-of-War.

Many mistakes appear to have arisen in making the calculations for ascertaining the exact amount of steam power required for any particular ship. The source of these mistakes has often been sufficiently obvious, and the greatest uncertainty will always prevail as to results, where there has not been the most accurate estimate of the differences of resistance consequent upon different formations of vessels, as well as taking into account the capability of the ship when fitted with an engine for carrying weight.

The error has been sometimes committed of putting too great power on board of our steam-ships as at present planned.

The Diadem, with 800 nominal horse power, although a noble ship, is quite a case in point. In perfectly smooth water and little wind (force 3) it required an indicated horse power of 2·390, or in other words, nearly three times the nominal horse power, together with a consumption of 60 tons per day, to obtain 9·9 knots from the Diadem.

The following is an important example, to show that the length of a ship may be increased, that 300 tons more weight may be placed on board, the immersed midship section being unaltered, and yet that the speed may remain the same, with the same engines and boilers. The Peninsular and Oriental Company's ship Candia before being lengthened was 280 feet long, and her trial at the measured mile in Stoke's Bay gave 12·5 knots. This vessel was lengthened 35 feet before the midship section, and on her second trial had 300 tons more weight on board than on her first trial. Her second trial took place on the 12th August 1857, also at Stoke's Bay, and the speed of the Candia was then 12·45 knots.

Surveyor's Reply.

It appears from the tenor of the remarks of the committee on the forms of ships, that they suppose there are some persons holding office in the government service, and who, having made this subject their especial study, and being well acquainted with the dimensions, forms, and other elements of Her Majesty's ships, and of many others, as well as with a vast number of authentic facts relating to their actual performances, are not yet aware that fineness of lines is conducive to velocity, and essential to high velocity. Such an opinion, however, it may be confidently stated, is altogether erroneous.

Our frigates have now reached the length of 300 feet. Almost the first of the large ships designed especially for the screw were the Duke of Wellington, Agamemnon, and Imperieuse, when a considerable step was taken; the Agamemnon having been made 230 feet in length; the longest sailing two-decker being only 205 feet. It being found that these ships sailed and worked quite as well as the ordinary sailing ships of the same classes, it was decided to make a further step in this direction; and, in consequence, the Renown was built of the still greater length of 245 feet, to enable her to receive larger and more powerful engines than the Agamemnon, and to give her finer lines with a view to increased speed under steam. The trial of the Renown having proved so far satisfactory, it has been decided to take a yet further step by building the Bulwark, and other ships of this class, of the still greater length of 252 feet, for the purpose solely of making them of still finer forms for greater speed. High speed under steam is, in the present day, considered of such paramount importance, that no reasonable expense should be spared, nor means left unresorted to, which are likely to accomplish it, provided the sailing and other essential properties of ships are left intact.

But in still further increasing the length of ships there is another and very important consideration, whether, looking at the fineness of their extremities, and weight of their machinery, it will be possible to make ships built of wood of sufficient strength to retain their forms for any length of time. It has always been felt that it is by means of experiments at sea chiefly that any reasonable expectations can be entertained of advancing the art of designing ships and their machinery, and with this view, experimental trials of ships have been made from time to time when their services could be spared; but the absolute necessity for such experiments has been still more felt since the introduction of the screw, for this has rendered necessary an entire change in size, proportion, and form of ships, in consequenee of the enormous bulk and weight of their machinery and coals, and of their being required to sail well, to steam well, and also to behave well under sail and steam combined.

Far more complex and difficult considerations are thus introduced, and almost incompatible conditions required: in fact, so complete a change has been made in Her Majesty's navy within the last few years, that the former accumulated experience derived from the behaviour of sailing ships becomes comparatively useless as a guide for the construction of modern steam-ships.

Data, however, founded on the actual performance of these ships at sea are now fast accumulating, and it may be expected that the conclusions drawn from them and from an elaborate comparison of the lines and calculated elements of ships of different classes, will gradually but surely point out the nature of the improvements which are still needed, and the best mode of effecting them. Immediately connected with this subject is that of the engine power which ought to be used. This is also an important question, and one involving difficult considerations, which experience and observation will alone help us to deal with satisfactorily. It by no means follows, that because a vessel carries a wave before her when urged to the utmost at the measured mile, she has more power than can generally be used advantageously. This is an exceptional case, and should not of itself be taken as a criterion of the proper amount of power required for general use. A certain speed for every particular class of vessel may be regarded as essential, at which speed the power placed in her should be capable of propelling her under ordinary circumstances without difficulty.

The rule generally has been to place in ships of war as much power as the displacement and general arrangements connected with the necessary stowage of the ships admit of being placed in them, and in no instance has the amount of power so determined been reported too great by the officers who have commanded such vessels; but, on the contrary, complaints have been sometimes made of its being insufficient.

The next case of too great power, in reference to form, is that of the Diadem. At the time when the design was made for this ship a strong feeling was entertained against increasing the length of ships, both on account of the additional cost of their construction and of the difficulty which might attend the working of them under sail, together with the greater dock and basin room they would require. These considerations have prevailed up to within a short period to prevent the lengthening of ships sufficiently to enable suitable forms to be given them for attaining high speed, except with some sacrifice of power. The Diadem, it may however be observed, was designed originally for 600 H.P. engines, and 800 H.P. engines were subsequently ordered to be placed in her, because the French were then placing engines of this power in their 50-gun frigates of about the same length. In fact, the only important question is, is the Diadem a better ship with 800 H.P. than she would be with 600, or any less amount of power? It is assumed that few practical men would hesitate in answering this question in the affirmative.

It must not however be supposed, from anything that has been said upon the subject of placing great power on board un-

Digitized by Google

suitable ships, that the committee are not desirous of guarding against the opposite extreme, namely, that of placing only very small steam power in ships, merely because they have not good lines of construction. A certain degree of speed for a man-of-war has now become essential; and in converting old sailing ships into screw steam-ships, the nominal horse power that ought to be placed on board each ship must be carefully considered in reference to the size and lines of the particular case. For instance, from the size and formation of the Queen it would probably be advantageous to place 100 nominal horse power more than should be placed on board some of the other line-of-battle ships that are being converted.

Surveyor's Reply.

The question here raised is not one of opinion, but of fact, namely, the internal capacities of the several ships referred to. This was of course ascertained in the first instance, before any suggestion was made to the board respecting their conversion into screw-ships, and if the committee had communicated their intention of expressing their opinion on the subject, the necessary information would have been freely furnished to them; and they would thus have been prevented from making loose statements, so calculated at first to convey erroneous and unjust impressions, but afterwards to lessen the confidence which the statements and opinions of a committee generally command. Instead of the Queen being capable of carrying larger engines than the other three ships, she is in fact the least capable; she has actually less available displacement than any of them, and less internal space.

The Screw as a Propeller.

Various forms of screw propellers have at different times been proposed, and various experiments made as to their respective utility; but from all these it does not appear that any form that has ever been applied to our men-of-war is superior for the purposes of propulsion to that of the common two-bladed screw, supposing, of course, that the proper pitch and diameter applicable to the vessel has been arranged. It has also the advantage of being more easily hoisted up than the three-bladed screw.

The attention of the committee was directed to the consideration of the qualities of Griffith's screw, and as its pitch is capable of being altered, they recommend its use for determining the most suitable pitch where a common screw is to be fitted for any particular ship.

There is one detail of considerable importance which the committee would recommend, more particularly as in the greater number of our screw ships the plan has been adopted, and found to answer well; it is this, that the screw shaft shall not draw in, but be fitted with a T head.

The committee cannot close these brief remarks upon this subject without strongly urging that the purchase of screw propellers should be at once abandoned, and that they should be all made at the government factories. The brass screw, on Griffith's plan, intended for the Doris, cost £637 more than it could have been furnished for at one of our own factories. And taking a general average, it will be found that upon this article of steam machinery a saving may be effected by government being their own constructors, to the amount of at least 30 per cent. upon the price at present paid, besides the certainty of having the best articles that the country can produce.

Admiralty, 24 December 1858.

In returning the Report of the Committee on Steam, their Lordships' attention is called to the observations therein made agreeably to their directions.

As regards matters of great importance, and these are comparatively few, a perusal will show in what respects the committee and the surveyor agree in opinion, and in what respects they differ.

For instance, there is a perfect agreement in opinion as to the excellence of the engines obtained for Her Majesty's ships, and as to the reasonableness of the price paid for them; but not as to the propriety of setting aside approved plans in favour of some engine to be designed by Admiralty officers, or as to the policy of setting aside the approved makers of these engines, in order to employ others to manufacture the same kind: nor do they agree in the opinion as to the policy of extending the system of manufacturing machinery in the dockyards to such a degree as would have the effect of increasing the cost of maintaining the factories by at least one-half the sum which, under the existing practice, would be voted for the purchase of new engines and boilers.

There is also no difference of opinion as to the praiseworthy manner in which the principal engine-makers acquited themselves of the trust reposed in them during the exigencies of the Russian war.

The surveyor of course agrees with the committee in their conclusion, that from what they have seen in the proceedings now adopted by the steam authorities of the navy, there is no appearance. at least for the present, of what they term "grave errors" being repeated.

With respect to the fineness of ships' forms, and the engine power which ought to be used, the committee, as might be expected, express themselves vaguely, but they seem to hint an opinion in favour of increasing the fineness of forms, and of putting engines of less power into the ordinary class of ships. Now this being a complex subject, it has been dealt with elsewhere at some length. It may be sufficient here to observe, that already frigates reach the length of 300 feet, which is necessary to give them fine extremities. Ultimately, perhaps, to keep pace with our rivals, they must be made longer still.

However this may be, it is confidently believed that no report has ever been received from an officer commanding a ship that she had too much power, unless she was unable properly to carry it, and for this clear reason, that he need not use it unless he choose to do so; and when he does not use it, which is always the case except when a great object is to be effected, he burns no more coal than if the engine were incapable of exerting a greater amount of power. Here again we must in some degree be guided by the practice which obtains on the continent.

(Signed) B. W. Walker.

THE EXHIBITION OF MR. DAVID COX'S PICTURES, SKETCHES, AND WATER-COLOUR DRAWINGS.

Few art exhibitions are more interesting—none more instructive—than those devoted to the works of one great artist exclusively. Each work is a key to the excellences and intentions of each other work; and the whole series may be considered to represent the history and progressive development of one great artistic mind. Unfortunately for the lovers of art, such exhibitions are very rare. The productions of important authors find their permanent place in the collections of connoisseurs, and are therefore, in a great measure, inaccessible to the general public. Almost necessarily then any collection of the works of an artist must be of a transitory and fragmentary character.

It has long been desired to remedy this great want, and to afford to the amateur, the artist, and the public the opportunity of seeing some of the finest specimens of some of our most renowned artists in the collected arrangement of one exhibition. To effect this, a number of gentlemen have formed themselves into a committee, and have made arrangements to present for a period in every year such an exhibition as is above suggested. From a casual circumstance the first choice has fallen upon the works of that simple and grand painter of English rural scenery and country life, David Cox; and the committee, having had placed at their disposal the German Gallery in New Bond-street, for a short period, in the first place opened the exhibition there; but that room being now required by the proprietor, it has been removed to 120, Pall-mall, and occupies the suite of rooms on the first and second floors. As may be conjectured, the removal thus necessitated is not so favourable for a good view of the pictures; the lighting of the rooms being derived wholly from the windows at the extreme ends: consequently, as many of the pictures are hung above the eye-level, and are not unfrequently small in size, they are not likely to gain all the attention which they really merit. We are aware however of the utter impossibility of securing suitable premises for such a purpose now that the picture season is so fully inaugurated, and though we cannot but draw the comparison between these pictures in their new locality and in that where they were on view till a week or two ago, we are rejoiced that so praiseworthy an object has been attempted, and so successfully accomplished. It may be mentioned, that while providing for the lovers of art so great a treat, the committee are most desirous to have it distinctly understood that the exhibition is in no sense a commercial speculation. The receipts will be devoted to defraying the necessary expenses, and whatever surplus may remain will be handed over to the Artists' General Benevolent Fund.

Altogether the collection will be found a highly interesting one, although the bent of the artist's mind and talents has led him into what might be thought a very monotonous style of subjects; but here the hand of genius triumphs, and invests even repetitions with a charm. A very favourite scene with our painter was always the Vale of Clywd, and even in this imperfect series of his works it forms the specific title of three pictures, while a similar character of landscape pervades some dozen or more besides. Welsh grandeur is Mr. Cox's especial study and delight: the proofs of this are manifold, and whether it be in the portrayal of a peaceful vale like Clywd or Dolydellan, or the

Digitized by Google

over-awing wonders of Penman Mawr, he is equally at home. Several noble views of our English castles will be regarded with pleasure, such as Windsor (2 views), Beeston, Barden, Dover (a very slight but beautiful sketch), Kenilworth, Dudley, Richmond, Bolsover, and Lancaster. The view of Rhyl gives an excellent opportunity for displaying our artist's skill in representing truthfully, without exaggeration, that most difficult object, the sea. We know not which of all the number—amounting to 174—is to be regarded as his earliest production, but we recognise that "On the moors, near Bettwys y Coed," as having graced the walls of the Old Water-colour Gallery so late as last season.

This exhibition is indebted to not fewer than thirty-four gentlemen for the loan of pictures, and it is stated that other portfolios of sketches and additional drawings have also been received, which will still further enhance the attraction.

SOME ACCOUNT OF THE LIFE AND WORKS OF BALDASSARE PERUZZI.

By Samuel Angell.*

In the notice of the life of Le Tarouilly, prefixed to 'Les Edifices de Rome Moderne' (the noble work of that indefatigable architect and author), it is remarked that although he possessed a just admiration for the works of Bramante, San Gallo and Vignola, the artist he preferred was Baldassare Peruzzi; and so great was the admiration of Le Tarouilly for this "artista valente" (as he is styled by Milizia) that he compares him to Raffaelle, from the resemblance he found in their characters and in the nature of their talents. The preference evinced by such excellent authority, and by one so eminently qualified from the direction of his labours and studies to form a correct judgment, has induced me to bring to your notice the works of Peruzzi, feeling assured that there are still among you some who have not been entirely led away from their early studies of Italian architecture, and that even from the Mediæval benches (crowded, and so honourably occupied as they are upon this evening of their triumph) I might possibly enlist some sympathy, if not admiration, for so distinguished an architect of the Renaissance period as Baldassare Peruzzi. Peruzzi was born early in the year 1481 at Accajano, near Siena, and he was sometimes called "Baldassare de Siena," but Vasari states, that both Florence and Volterra (as well as Siena) put in their respective claims for the honour of his birthplace. I believe, however, that we shall not be in error in considering him a Sanese. His early days appear to have been passed in the workships of goldsmiths and jewellers, after which he commenced the study of painting, copying and imitating the works of the best masters, as well as drawing from nature; and upon the death of his father, about this period, his exertions and progress were such, that he was enabled to support himself by his art, and to aid both his mother and sister. We may remark that it is probable his early studies as a painter (more particularly those of a decorative character) produced in him afterwards that freedom and facility in his architectural designs for interior ornamentation, of which he has given us such exquisite specimens in the Massimi Palaces, and other of his works. I regret that I have not sufficient data to place before you the works of Peruzzi in chronological order. I will adopt, therefore, the arrangement in which they are classed by Vasari, who informs us that Baldassare's first work (after some few unimportant ones at Siena) was a small chapel, near the Florentine gate at Volterra, where he painted certain figures with "infinite grace," after which he proceeded to Rome with his friend and brother artist, Pietro da Volterra. Peruzzi's early days at Rome appear to have been devoted to his studies as a painter, and he obtained great praise for the excellent manner in which he executed in fresco the Chapel of the Great Altar in the church of San Onofrio. He was next engaged in painting two small chapels in the church of San Rocco a Ripa, and having now attained some eminence, he was invited to Ostia, where he executed some beautiful historical representations in chiaroscuro, in the apartments of the tower of the fortress. Many of these represented combats, in which were introduced ancient armour and equipments of war. These decorative paintings are considered among the best of Peruzzi's works in that style, though it is but fair to state that he was assisted in them by Cesare, of Milan. Upon the completion of his labours at Ostia, our artist returned to Rome. His chief architectural work at this time was the celebrated "Farnesina Palace," for Agostino Chigi, on the Lungara. Le Tarouilly gives 1510 as the date of this admirable production, a work to which Vasari applied the happy expression of "Non murato, ma veramente nato." Situated as the building is upon the spot formerly occupied by the gardens of the Emperor Geta, Baldassare composed his plan upon the most simple arrangement, evidently considering it as devoted to pleasure and entertainment, rather than for a domestic residence. Le Tarouilly's three plates convey an admirable description of the edifice, with the sole exception that one of its most attractive features (the exquisite colouring of the ornamentation) is not rendered; this omission, however, is in a great measure supplied by the beautiful coloured plate in M. Gruner's noble volume, and in the Italian prints tinted in body colour.

The Farnesina owes much of its celebrity to the beautifnl pictorial embellishments of those eminent masters, Raffaelle, Giulio Romano, Sebastiano del Piombo, Daniele da Volterra, and Annibale Caracci; and, with all his fond preference for Peruzzi, Le Tarouilly allows that many parts of the exterior architecture are open to criticism; the design however is full of grace and elegance, and the ornamentation is deserving of all praise. Great portion of the enrichments in "terretta" are by Peruzzi's own hand, and the great Titian himself is said to have been deceived by the marvellous imitations of relievos. Peruzzi was next employed, according to Vasari, in executing a façade in "terretta" between the campo de' Fiori and the Piazza Giudea. It is described as an admirable performance, particularly the perspective views which were introduced in it. This work was a commission from one of the pope's chamberlains. In the Chiesa della Pace our artist painted a chapel for Messer Fernando Ponzetti (who was afterwards made a cardinal); he also painted in "fresco," in the same church, a picture for Messer Filippo da Siena, representing the Virgin ascending the steps of the temple; this picture contained a great variety of buildings, with many beautiful ornaments of various kinds.

The Palazzo Costa in the Borgo Novo (built for Jacobus Brixianus, surgeon to Leo X.) is not far distant from St. Peter's. Some attribute the architecture of it to Raffaelle, but Le Tarouilly (the best authority upon such points) is inclined to ascribe it to Peruzzi. The design is of an unpretending character, and the ground floor (as in many instances in the Italian palaces) is occupied by shops. Much study has been given to this design, particularly to the rustication, and it is upon the whole well deserving the attention of the student. The author of 'Les Edifices de Rome Moderne' has devoted three plates to the Palazzo Linotte, in the Vicolo dell' Aquila. This palace is situated near the Cancelleria (the great work of Bramante), but little is known of its date or history, and it is attributed to Peruzzi more from its style than from any authentic source. It has been ascribed also to Bramante, and to Michael Angelo, but there are no traces of the distinctive styles of those architects, and if not the work of Peruzzi, the claims of San Gallo I believe would be considered as most worthy.

The Palazzo Ossoli, in the Via de' Balestraji, is attributed to, rather than positively known to be the work of Baldassare. The simple and masterly arrangement of the plan, and the elegance of the façade partake of the master mind and hand of Peruzzi, and I think there can be no doubt that Le Tarouilly is correct in naming him as the architect.

The Chigi Chapel in the church of Santa Maria del Popolo, has been generally attributed (both as to its architecture and pictorial embellishments) to Raffaelle; but we owe it to the study and research of Le Tarouilly, supported by the opinion of his countryman Lalande, that the architecture is from the hand of Baldassare; the style and imprint are his, and the "Corinthian Order," as published by his pupil, Serlio, resembles in a great degree the one that has here been employed. Peruzzi's intimate friendship with Agostino Chigi may be fairly adduced as an additional reason for believing that he was employed in this chapel as architect, while Raffaelle (as in the Farnesina) was commissioned with the pictorial embellishments. This chapel is certainly a "Capo d'Opera!" and although I may be venturing upon tender ground this evening, in daring to uphold the Italian architecture of the XVIth century for ecclesiastical purposes, I am bold enough to admire this fine specimen of the taste and genius of Peruzzi, enriched by the master hand of the divine Raffaelle, and to join in the enthusiastic language of Le Tarouilly, "Honour

* Paper read at the Royal Institute of British Architects.

Digitized by Google

then to Chigi, to whom we owe this *chef d'œuvre*, and who has immortalised himself by joining his name to those of the two great artists, to whom he was the Mecænas!"

About this period (1520) Peruzzi appears to have been invited to Bologna, to enter into the famous competition for the designs for the façade of the church of San Petronio; an event which appears to have excited as much interest in those days, as the struggle for the Government Offices or the Spurgeon Tabernacle in our own times. We learn that Peruzzi sent in two designs, the one Italian and the other Gothic; they are still preserved in the sacristy of the church, and Vasari is loud in his praises of a perspective view; this, I presume, applied to the Italian design, for I suspect Baldassare was more at home with the five orders than he was with the pointed arch, and buttress, and pinnacle of the Mediævalists. While at Bologna, Peruzzi designed the portal of the church of San Michele, in Bosco, and embellished the monastery of the monks di Monte Oliveto, in the environs of Bologna. The cathedral at Carpi was also designed by Peruzzi at this period. For the Count Battista Bentivogli he made a design in chiaroscuro, "The Nativity of Christ and the Adoration of the Magi." As this drawing is now in our own national collection, we ought to be enabled to judge whether its merits deserve the encomiums Vasari has bestowed upon it, but unfortunately it is placed in so dark a position on the staircase as to be quite invisible to the eye of criticism. The catalogue, however, throws some little light upon its history, for we learn from it that the drawing was made in 1521, and was engraved on wood by Agostino Caracci in 1579. The three Magi are portraits of Titian, Raffaelle, and Michael Angelo.

While commencing the church of San Nicolo, at Carpi, our "painter architect" was called upon to enter a new sphere of action, and to bring to bear his engineering knowledge in planning and superintending the fortifications for the defence of his native city, Siena. Upon the completion of these works, Peruzzi again repaired to Rome, where, upon the death of Raffaelle in 1520, Leo X. appointed him architect to St. Peter's, when he was called upon to design a new model, upon which it is said he employed so much talent and skill, that even the fastidious Milizia considered it worthy of praise. Serlio (who was Baldassare's pupil) describes the plan to have been a Greek cross, terminated at each extremity by a semi-circular apse. There were four square sacristies, over which campanili could be erected. At each extremity of the cross was a semi-circular porch, through which, by three openings composed with four detached columns, was an entrance to the building. The great altar was in the centre, surrounded by four large piers, supporting a cupola 138 feet in diameter (within one foot of that since executed). Each of the four naves had two side aisles, with cupolas at their intersections 48 feet in diameter.

The tomb of Adrian VI. in the Chiesa dell' Anima, is the work of Peruzzi; and the Vigna of Papa Giulio, on the Flaminian way, although ascribed to Sansovino by Vasari, is considered by Le Tarouilly as the work of Baldassare. It is a most charming and elegant composition, and we are at a loss which to admire the most, the grace and simplicity of the whole, or the exquisite delicacy of the detail. Peruzzi's genius appears to have been nearly universal, for we next find him engaged painting two scenes for the representation of the "Calandra," a drama written by the Cardinal Bibiena, and performed before the pope: these scenes are said to have served as models for whatever has been since done of that kind. The preparations for the coronation of Clement VIII. were also entrusted to the care of Peruzzi in 1524. A small palace in the Via Giulia, at Rome, is also given to us by the indefatigable author of 'Les Edifices de Rome Moderne,' as the work of Peruzzi, and it presents an excellent specimen of the great extent to which external ornamentation was formerly carried. The decorations are described to have been in some instances in "fresco," and in others, painted in imitation of bronze and gilt, and portions are said to have been executed by Baldassare's own hand: they are composed in a grand style, and after the manner of the antique. The fresco figures were still tolerably preserved in 1823. The doorway under the vestibule of this palace is made to diminish in width upwards; the same method has been adopted by San Gallo, at the Palazzo Farnese; and upon this Le Tarouilly remarks, "that at this epoch (the XVIth century), when there was a general feeling for the antique, and when the cultivation of the ancient art had become as it were the true religion among all the professors; when learned commissions were instituted to make commentaries upon Vitruvius, it is not to be wondered at, that the two eminent architects, Peruzzi and San Gallo, studying together the ancient monuments, should about the same time have made the same application from what they had studied."

About this period Peruzzi executed the beautiful altar, and the chapel of St. John the Baptist, in the cathedral of Siena. The villa Belcarro, near that city, and the fine portal of the Sacrati Palace at Ferrara, were also designed by him at this date, and it was probably about this time that he painted his celebrated picture for the church of Fonte Giusta, at Siena, representing "the Sibyl announcing to Augustus the birth of Christ," which is said to be his masterpiece. So highly was this picture esteemed by Lanzi, that he says, "the painter gave it so divine an enthusiasm, that Raffaelle, treating the same subject, as well as Guido and Guercino (whose Sybils are so often met with) probably never surpassed it." Forsyth describes this picture in the following terms: "Peruzzi's Sibyl at Fonte Giusta is a sublime figure, but, perhaps, too sedate for the act of prophecy." We now arrive at the greatest as well as the last and crowning work of Peruzzi, the pyramidion of his fame—the celebrated Palazzo Massimi.

The architect to the Massimi Palaces, in the adaptation of his plan to the limited and perplexing site, and the obligation to preserve existing foundations, under injudicious notions of economy, had no common difficulties to contend with; but the genius and invention of Baldassare overcame all obstacles. The curved line of the frontage, which would have been to many a "pons asinorum," was rendered by him a "pons triumphalis."

Many of the Roman palaces are upon a larger scale than this, and are more imposing in their exterior architecture, but I doubt whether for beauty and grace of ornamentation any can compare with the Massimi. The strict injunctions to economise prevented Peruzzi from employing any expensive or rare materials, for, with the exception of two marble columns only, in the loggia of the Piano Nobile, the construction is of Travertine stone, of brickwork faced with stucco, and of wood. This example is cited as a lesson of economy; and when we consider that the exquisite enrichments derive all their beauty and elegance from the masterly design and execution, without any aid from expensive materials or costly adjuncts, we may well join in the homage that has been bestowed upon Peruzzi by French architects. I have already had occasion to remark that more than three centuries have elapsed from the period of building the Massimi palace to the time when Le Tarouilly was engaged in carefully measuring and taking note of every portion still remaining, and at the date of his labours, some thirty-five years since, when I had the gratification of being in Rome, the Massimi was generally in a fair state of preservation; but I am grieved to say that it now no longer remains so, for my excellent friend and our esteemed brother Fellow, Mr. John Davies, who last year made a pilgrimage to Italy, and revisited the scenes of his early studies after an interval of some thirty-seven years, thus describes the present state of the palace: "When I was in Rome, in October last, I went all over the Massimi, and was grieved to see the shameful state in which it was, the beautiful open vestibule and ceiling next the street falling to pieces." Le Tarouilly concludes his notice of Peruzzi in these terms: "It was about the year 1532 that Peruzzi commenced the Massimi palaces, and at that period he was in the full energy of his talents. The taste and infinite variety he has displayed in the ornamentation are a proof how well he accomplished the work studied by him in the most minute details. Poor Peruzzi died in 1536, at the age of fifty-five, in a state bordering upon misery. We cannot be altogether surprised at this melancholy termination he had to labour for a numerous family, and his income was never proportionate to his merits or his services. According to Vasari, the rich personages who profited by his talents took advantage of the gentleness of his character, his modesty and extreme reserve, and they thought less of recompensing the artist, than they did of praising his works.

Peruzzi's most distinguished pupil was Sebastiano Serlio, who was twenty years of age at the time of the lamentable death of his unfortunate master. Serlio remained in Italy three years after this event, and then proceeded to France; where he executed, together with Pierre Lescot, Jean Bullant, and Philibert Delorme (all worthy students of the same school) some of the finest works in architecture that France possesses of that period, and it is I believe principally owing to the careful study of the works of such master minds as Vignola, Peruzzi, and their disciples, that the French architects have acquired that exquisite taste in orna-

Digitized by Google

mentation so prominent in all their works. It is to the same pure sources that I would most earnestly entreat the students of our own country to have recourse, looking forward to receive the grateful tribute to talent by their brother architects, as in the distinguished instance we have had before us this evening, rather than being deterred by reflecting on the misfortunes sometimes attendant upon genius, as in the case of poor Baldassare Peruzzi.

INSTITUTION OF CIVIL ENGINEERS.

J. Locke, Esq., M.P., President, in the Chair.

April 12.—The whole of the evening was occupied by the discussion of Mr. McMaster's paper, "*On the Permanent Way of the Madras Railway.*"

It was remarked that, for India and other similar countries, the ordinary chair-and-sleeper road was not yet ascertained to be the best that could be adopted. In such cases it was desirable to aim at obtaining the smallest number of pieces, simplicity of parts, and avoiding complicated fittings. The arrangements should be made with a view to guard against peculation, as well as to the best mechanical construction; for the natives were apt to steal fishing plates and bolts. It was contended that the single-headed rail, fixed directly upon the sleepers, and with a sufficiently broad flange to prevent injury to them, was preferable. This form of rail had been extensively used in Germany and the United States of America, and the application of the "fish" rendered the joints much more secure and the surface more uniform. It was urged that the quality of the materials and the machinery to be sent to India and other distant places should be carefully attended to, as the heavy charges for freight and shipment formed a large portion of the expense. In this view it was thought that the double-headed rail first introduced by the President, provided that it was so laid as to be capable of being reversed, possessed great advantages. It was believed that rails weighing 60 lb. to the yard, to which an additional hammering had been given during the process of manufacture, would answer well for lines where very high speeds were not essential, and that their use would be attended with economy.

Allusion was made to a system of enabling the double-headed rail to be used without chairs. This was by suspending the rails between a pair of longitudinal balks, contoured to the rail channels. The rail and timbers were bolted together by flat bolts, 3 feet apart. The joints of the rails were connected by brackets of angle iron to a cross tie of timber. By this plan a thinner web could be used, and therefore a deeper rail for a given weight. When it was wished to reverse the rail, it was not necessary to disconnect the rails and the timbers, but merely to take out the joint bolts. It was believed that this system would induce economy, as no chairs were used, and less timber and ballast would be required than on an ordinary cross-sleeper road. A length of 150 yards of this way had been laid for six months on the main Cambridge line, at Stratford, where the ballast was bad and the traffic great. The timber used was only cross-sleepers cut down the middle. It made a good road, and there was a perceptible difference in passing on to it from the other portions of the line.

It had been stated that the compressed keys were liable to shrink in hot climates, and that some which had been allowed to remain on the sea coast in India had swollen so much as to be unfit for use. On the Lisbon and Santarem Railway, an oaken key 10 inches in length and slightly tapered had been substituted; and this plan was about to be tried on the Madras Railway. The employment of an iron key, with a thin cushion of wood between it and the chair, the timber being cut across the grain, was suggested as an alternative. In defence of compressed keys it was remarked, that what had been stated was scarcely so much the necessary cause of the defect of the key, as the way in which the keys were used. Twenty millions of these fastenings had been supplied for the railways in India, or sufficient to lay 2200 miles of road, and no complaint had ever been made until quite recently. The author of the paper had said, that the compressed keys lasted better than those which were unprepared; and it was also believed that the loss from premature expansion had been inappreciable during the period of three or four years during which they had been used on the Madras Railway. But being aware that the amount of dry heat to which they would be subjected, with iron on both sides of them, might have a tendency to cause even compressed keys to shrink, until they were thoroughly saturated with moisture, they had lately been made larger than usual, so as to receive a greater degree of compression. It was understood, that hundreds of casks of keys had been lying exposed to the heat of the sun for months after their delivery in India, and until the staves of the casks opened. If there had been any expansion of the tightly packed keys, the casks would have been burst open. With proper care however it was maintained that they would have remained without fault.

It was thought that one of the main points arising out of the paper was, whether it was desirable to construct permanent way in India with timber or with iron sleepers. As the cost of renewal irrespective of ordinary maintenance amounted on lines in this country to £100 per mile per annum, of which sum about 37 per cent. was for the renewal of the rails, and 63 per cent. for the substructure, attention had been directed to the use of cast-iron for sleepers, which had been proposed and tried in many different forms. In Egypt, Greave's spheroidal cast-iron sleeper with the chair cast upon it had been found best suited to the soil and climate. There was little or no ballast on the course of the line, so that it would have been difficult to have found a foundation for the ordinary sleeper. Trough sleepers of cast-iron, in which the rail was suspended between linings or cushions of timber, so that in the case of the double-headed rail the lower table was not injured, and the rail could therefore be reversed, had been in use for nine years on the Eastern Counties, and for two years on the South Eastern and the Midland Railways. In the latter case they were laid near to the Derby station, where they were subject to a traffic of 550 engines, 2400 waggons, and 120 carriages, every twenty-four hours. A modification of these two forms, which might be denominated the "cup-trough," had recently been proposed, in which the chair was entirely dispensed with, so that there were no projecting parts liable to fracture. Tie-rods passed through the neutral axis of the rail, with square washers of unequal thickness placed in the side channels, secured both the angle and the gauge. This form of sleeper was stated to be applicable to any ordinary section of rail, without alteration of pattern; was said to be inexpensive in manufacture, and to be easily maintained, as it was packed through dormer holes at the sides, which were believed to afford greater facility than holes at or near the top. For shipment they could be stowed into one another, and save space. It was assumed that the first cost of a substructure on this system would amount to £910 per mile of single way, and on the ordinary system to £551 per mile, taking the cross sleepers at 4s. each, and the chairs at £4 10s. per ton. But it was contended that the timber sleepers would require to be renewed twice in twenty-one years; for although the timber might be rendered chemically durable, the destruction would go on nevertheless, and when the time arrived for the renewal the timber would be valueless, whilst the cast-iron would be worth two-thirds of its original value. It had been estimated that the saving, by the use of iron, would amount to £1058 per mile of single line, in a period of twenty-one years, after allowing interest for the original outlay in both cases.

In regard to the durability of timber sleepers, it was asserted that when properly creosoted they lasted much longer than would be inferred from the comparison just made. Scotch fir sleepers, laid on the Eastern Counties in 1841, had remained perfect to the present time, not one having been removed on account of decay. Between the years 1840 and 1842, creosoted sleepers had been laid on the Manchester and Crewe, which were still sound; and indeed, in re-laying the line with heavier rails two years back, some sleepers that had been in wear sixteen years were employed. The sleepers for the East Indian railway were weighed previously to being placed in and when taken out of the cylinder, in which they remained twenty-four hours under a pressure of 124 lb. to the inch, in order that 10 lb. of creosote per cubit foot might be forced into them. Some triangular creosoted timbers, which had been sent to India, had shown symptoms of decay, due, it was believed, to their being of hard wood, and to the form not being the best for the purpose, as the angles were liable to be damaged, and thus expose the uncreosoted portion of the wood. Timber should be stacked and properly seasoned before being creosoted, and it had been found that heart-wood was not so easily creosoted as young sappy wood, as it was impossible to make it absorb the necessary quantity to preserve it thoroughly. In the latter case, after a few years the creosote set into a solid bituminous mass; but only the thin and volatile portions entered heart-wood, and these were liable to evaporate quickly when the sleepers were used in a hot climate. Specimens of sleepers which had been "Burnettised" in 1841, and laid at that time on the Eastern Counties Railway, were shown to be quite sound at the present time. With respect to unprepared wood, instances were given of the sleepers having been said to have lasted many years, but the evidence was not conclusive. It was stated, that good sound larch sleepers were in some cases preferable to Scotch fir that had been creosoted, and that it would last equally long. It was observed that it was impossible to subscribe to the principle which had been advocated, that wood of the lowest quality, or young timber full of sap, and which sucked up a large quantity of creosote oil, should be selected for use, because it was favourable for creosoting. It was believed that the best results would be obtained when the utmost care was taken in selecting the woods. A good result was tolerably certain under these circumstances, and in corroboration it was mentioned, that timber laid in 1835, some of which was Kyanised, although the preparation merely entered to the depth of one-tenth of an inch, and some of which was unprepared, had lasted to the present time. St. John's yellow pine had been proved to be one of the most durable woods, both for railway sleepers and marine works. At the Liverpool and Sunderland Docks there were instances of its being quite fresh after being in use twenty years.

With regard to marine works, it was said that the worm would not touch timber which was creosoted to the depth of two or three inches around the pile. When however this coat was cut through, the worm would penetrate into the heart-wood, but when it reached the creosoted portion, it was stopped by the objectionable nature of that material. This had been proved to be the case at Lowestoft, where the creosote

Digitized by Google

was found to be generally a preservative against the ravages of the worm. In all cases the timber should be cut for framing before being creosoted. It was remarked that, although in general creosoting doubled the duration of the timber, yet the creosoted piles of the pier at Leith showed symptoms of being attacked by the worm. An instance was also mentioned of the worm penetrating a balk of creosoted Memel at Scrabster, Caithness, and having eaten through the blackened portion, although the pile had been in the sea for less than six months. To this it was replied, that the discolouration of the wood afforded no correct test of the timber having been properly creosoted; and it was suggested whether the work of destruction might not have commenced before the balk was creosoted, as there was hardly a log from Memel which was not more or less penetrated by some kind of worm. Kyanising was asserted to have no effect, as the corrosive sublimate combined with the sap of the wood, and formed a substance which was not poisonous, and could be eaten by the worms with impunity.

It was thought that sufficient stress had not been laid on the importance of utilising as far as possible the resources of the country in which the works were being carried out. In Ceylon, for instance, there were forests of almost interminable extent which might be made available. Eighteen different samples of timber had been examined, at least nine of which were applicable for railway sleepers in situations where they would be exposed to extreme variations of atmosphere and weather. The drainage of railways in tropical climates was a matter of the utmost importance, as the ballast was liable to be carried away by the heavy periodical rains. In reply it was intimated that the necessity for sending out timber sleepers to India arose from the circumstance that the supply there could not be relied on. There was great difficulty in determining the precise value and quality of woods in foreign countries, especially when such practices were carried on as steeping the wood in order to deceive, as had been the case in Madras.

In closing the discussion, the great diversity of opinion that still prevailed on this subject was commented upon. Every one appeared to think his own plan the best, and naturally preferred to be guided by his own experience rather than by that of others. As to the question of the durability of timber whether prepared or not, and, if prepared, then by what process, few persons were able to obtain reliable data as far back as twenty or thirty years. The Minutes of the Institution would contain a variety of opinions on this subject, but it was doubted whether the question could be solved, or whether there could ever be universal agreement as to what was the best system of permanent way to be used under all conditions.

After the meeting, Mr. Curtis explained a system of axle boxes, in which by centrifugal action the oil was constantly thrown over the upper side of the axle, and descending slowly upon the axle was returned again to the oil chamber. As soon as it had passed the axle, a piece of thin porous flannel placed at the bottom of the oil chamber was found in practice to answer as a filter to receive the parts of the metal, or other residuum resulting from the working of the boxes. These boxes were now at work on eight railways in England and on one in France. They had been in use for upwards of eighteen months; in some cases they had run for two months without any oil being applied; but the ordinary practice was to introduce about a wine-glass full of oil to each box once a week.

April 19.—The paper read was "*Description of the Entrance, Entrance Lock, and Jetty Walls, with the Wrought-iron Gates and Caisson, &c., of the Victoria (London) Docks.*" By W. J. KINGSBURY, A. Inst. C.E.

This paper had chiefly for its object to bring forward an account of some special works, which from their magnitude and peculiarity presented novelty and interest; it was therefore rather a contribution to the history of the Victoria Docks than an attempt to convey a complete idea of that undertaking.

The Victoria (London) Docks were briefly described as being situated in that part of the Plaistow Marshes, Essex, which, projecting forward towards the south-east, was bounded on three sides by the river Thames, which there formed a loop or bend, extending from Bugsby's Reach, just below Blackwall, to Galleon's Reach, below Woolwich.

The entire area comprised within the dock was shown to be about 200 acres, of which one half, or 100 acres, was water space. This consisted of the entrance, with its lock,—the tidal chamber of 16 acres, and the main dock of 74 acres. In general terms, the basin and dock together were 4050 feet in length and 1050 feet in width at the level of high-water mark.

In addition to the quay room afforded by the sides of the basin and dock, four jetties, each 581 feet long and 140 feet wide, were projected from the north side into the dock; these jetties, with the sides of the dock and of the basin, provided a length of three miles of quay space.

The general surface of the original marsh land was about 8 ft. 6 in. below Trinity high-water mark; and the tidal water of the Thames was always excluded by an embankment, which was maintained at a height of 5 feet above T. H. W. M.; that level was therefore adopted for the top of the copings of the entrance and of the lock walls. Taking T. H. W. M. as the datum, the bottom of the docks was stated to be 24 feet below datum,—the depth on the upper gate cill 25 ft. 6 in., and on the lower gate cill 28 feet, which latter depth was maintained throughout the entrance from the river; and as the mean fall of tide was 18 feet, there was a depth on the lower gate cill of 10 feet, and on the upper gate cill of 7 ft. 6 in. at Trinity low-water mark.

The subsoil was described as consisting of beds of yellow and blue clays, of varying thickness, and of a total depth of 5 or 6 feet, then a depth of from 5 to 12 feet of peat, and then a good bed of gravel overlying the London clay, which was found throughout the length of the lock at a nearly uniform depth of 37 feet below T. H. W. M.; and on this foundation, at a depth of 37 ft. 6 in., both the upper and the lower gate platforms were laid.

The sides of the entrance of the channel leading to the tidal basin and of the lock, were composed of concrete walls, faced with cast-iron piles and plates. The main piles were driven at intervals of 7 ft. 1 in. from centre to centre, the intervening space being filled by cast-iron plates, whose lower edge rested on the upper end of four cast-iron sheeting piles, which with them occupied the entire space between each pair of the main piles. These latter were each in two lengths; the lower 25 feet, and the upper 12 ft. 8 in., and the metal was about 2 inches thick, cast in a trough form, 18 inches in width. The sheeting piles were each 20 feet long, of similar form; the three interspacing iron plates for every bay were each 5 ft. 11 in. wide, and 5 feet deep, cast with back feathers to give the necessary strength, and provided with a top flange to carry the stone coping of the wharf. In the rear of each main pile, and at a distance of 18 feet from it, a timber land-tie, 20 feet long, was driven to a proper depth, and secured to the iron piles by two eyebolts and nuts, and behind them a wall of concrete was filled in, varying in thickness from 12 feet to 6 feet at the top, where the stone coping of the wharf was laid. The main piles were driven 5 feet into the ground, and the sheeting piles about 2 ft. 6 in. into the same stratum. Clay puddle and concrete were also used to render the lock chambers perfectly sound.

As the London clay was met with at a depth of 37 feet below T. H. W. M., advantage was taken of the circumstance to dispense with an invert at the gate platforms, by substituting ordinary brickwork. This was accomplished by laying open, down to the clay, the necessary areas for the upper and lower platforms—surrounding them by single rows of elm sheet piling 16 feet long and 9 inches thick, driven close, to a depth of about 7 feet into the solid clay; these were secured by walings, and within the spaces so secured the brickwork of the platform was laid. In this mode of construction it was essential to take out all the gravel; to lay the bricks directly upon the clay, and to use close piling, in order to prevent the possibility of any water getting beneath and blowing up the brickwork. Upon these platforms the side walls, which were 20 feet in thickness where they joined the concrete walls, were carried up in brickwork.

The hollow quoins for the gates, the external arris of the gate recess, the caisson quoins and cill, and the copings and bedstones for the anchors, which constituted the bulk of the stone work employed, were of a compact sandstone, called Duke's Quarry stone. The bricks used were almost all made from clay excavated from the site of the docks, laid in mortar composed of Halling lime and clean sharp sand; the latter also from the excavation, whence the gravel and sand used in the concrete also proceeded; so that these essential ingredients for the structure were found on the spot.

The paper then described the sluices and the pipes for filling and emptying the lock, with the precautions for examination and repair, and in general it appeared that every facility was provided for access to every part liable to wear and tear or injury, and for remedying all defects.

The cost of the piled and concrete wall of the lock chamber was stated to be £17. 0*s.* 7*d.* per foot run, and that of the entrance to be £19. 5*s.* 10*d.* per foot run, or £51 and £58 per yard run respectively. The price of the cast-iron at the time of the construction of the docks was £6 per ton; and the weight of iron averaged about 1¼ ton per foot lineal of the wall.

A description was then given of the three pair of lock gates—viz., the lower and upper gates of the entrance lock, and the inner gates separating the tidal basin from the main dock. All these were constructed of wrought-iron, nearly alike in dimensions and general arrangements. The objections to the use of timber were enumerated,—the introduction of cast-iron ribs, with timber planking, was noticed; and the gradual employment of wrought-iron for the frame, the plating, the diaphragms, and all the parts except the heel and mitre posts, was described. It was shown, that on account of the large dimensions of these gates, and more particularly their amount of curvature, timber would have been inapplicable; the lower gates being 80 feet in the span by 31 feet in height, with a versed sine of 20 feet, or one-fourth of the span. The form of the outer curve of the gates was an arc of a circle, having a radius of 50 feet; the distance between the skins, at the heel and mitre posts, was 2 feet, and at a point midway between them 3 feet, the inner boundary being two arcs of circles struck from centres 9 ft. 5½ in. apart, with a radius of 59 ft. 9½ in. There were fourteen horizontal diaphragms in each lower gate, the distances between them varying from 1 ft. 11 in. at the bottom, to 3 feet at the top. Beneath the bottom plate, which was ⅜ inch thick, a piece of timber to meet the shutting cill was fixed by bracket pieces. The horizontal diaphragms generally were ½ inch thick, and were attached to the skins by T and angle irons. There were also two vertical dia-

Digitized by Google

phragms passing continuously from top to bottom, and dividing each gate into three equal parts. These tended to prevent twisting, and added strength to the structure. The outside plating varied in thickness, according to the strain to which it was subjected, from ¾ inch at the bottom to ⅜ inch at the top. The plates were disposed with their lengths vertically, and all the joints were provided with strips on the outside and on the inside, to render the structure watertight.

The heel and mitre posts were of green-heart timber, and were firmly attached by angle irons and bolts to the gates. The chain attachments were made to draw upon both skins and upon the entire frame of each gate, and to be accessible at low water. The gates were opened and closed by Armstrong's hydraulic machinery.

The peculiar arrangements for the moveable handrails of such curved gates were then described; and it was shown, that by the use of swivel sockets the curved rail could be made to shut down quite close, to permit the passage of the towing ropes.

The pivots and foundations were then described, as were the shutting cills, with the means of securing them, the roller paths, and the rollers, the latter demanding peculiar arrangements, on account of the curved form of the gates and their great weight. They were so arranged as to be easily accessible outside the gate, and by releasing a nut the column which fitted into a recess in the upper part of the roller-frame could be removed, and the roller could be drawn up by chains in the guides, be examined and repaired if necessary, and be restored to its place, without disturbing the gates.

The large anchors were also fully described, as were the modes of securing them.

The upper and inner gates were stated to be somewhat lighter than the lower and outer gates, the material was thinner, and there were fewer horizontal diaphragms; in other respects all the gates were nearly identical. The inner gates were not worked by hydraulic power, and the sluicing was done directly through four apertures in each of the gates themselves, instead of through the side walls.

The weight of metal in the gates was—

Wrought Iron.

	Tons.
In the inner gates, including the cast-iron pivot stop piece... ...	198
Ditto in upper gates	128
,, inner gates ... ... (including sluices)	138

Cast Iron.

In the shutting cills, pivot crosses, anchors, rollers, roller paths, foundation plates, &c., with the bolts for each pair of gates ...	59

The ancient river bank, which was about 5 feet above T. H. W. M., and protected the marsh from the overflowing of the river into the low district, formed a natural dam, behind which the inner works of the lock chamber, the brickwork of the gate openings, and the other operations were carried on, and outside of which a considerable portion of the piling and the concrete walling was executed. But in order to effect the junction of the two portions, and to complete the entrance works, it was necessary to remove a large quantity of material by barrow, and then to resort to dredging below low-water mark. To admit of this being done simultaneously with the other works of the dock, it was essential to provide the means of keeping the water out of the dock whilst the river bank was broken through and carried away. A coffer-dam would have been expensive and tedious; recourse was therefore had to a caisson, which was constructed of wrought-iron plates, and from its great size and the peculiar mode of using it the description became very interesting. The ordinary form of a caisson was well known to be something like that of a ship, with a raking stem and stern, and fitting into grooves in the side-walls, whilst the keel applied itself close down against a shutting cill.

The new caisson was built of a rectangular form in its side elevation, the heel-posts being vertical and shaped like those of the gates, so as to fit into a hollow quoin, as into a kind of rebate. In plan it was similar to one leaf of the gates, being 3 feet wide in the middle and 2 feet at each end, and it was large enough to extend across the span of 80 feet between the lock walls; its curvature was not great, the rise or versed sine being 8 feet, the outer and inner curves being struck with radii of 94 ft. 8 in. and 104 feet respectively. The height of the caisson was 31 feet, and there were five horizontal close diaphragms in that height, including the bottom and top plates. It was thus divided into four spaces, the lowest of which was 4 ft. 1 in. high, the second was 9 ft. 2 in. the third 10 feet, and the fourth or upper space, 7 ft. 9 in. There were also two vertical diaphragms from the bottom to the top. The position of the lower horizontal diaphragm was designedly fixed, so that the internal capacity of the bottom space should be equal to 25 tons of water. There was a bottom lining piece of Memel timber to meet the shutting cill. There were also two rectangular sluices, one opening through the bottom lower compartment, by which the water could be admitted to fill the dock; and another of small area on the concave side, opening into the lower compartment, by which it could be filled when required. A three-throw pump, with gearing for emptying the caisson, was fixed on the top.

The hollow quoins for the caisson were built of Duke's Quarry stone, and were placed in the walls where they began to rake back from the perpendicular to meet the batter of the piling.

In using the caisson, its total weight being about 90 tons, if the water-space was pumped out it would float with the convex side downwards, nearly in a horizontal position. On the small sluice being opened, the water entered the bottom compartment, and caused the caisson to tilt gradually into a vertical position, during which time it was drawn towards its position between the quoins and the heel-posts fitted into them. Thus, with a caisson of this form and construction, no greater depth of water than just enough to float it was required to get it out of its place; and as soon as it was free from the quoins it could be turned on its back, so as to present very little surface to the wind, and in that position it was perfectly manageable.

The construction of the jetties, which had been already incidently noticed with regard to their position and general dimensions, was then described. The general form was that of a parallelogram, 497 feet long and 140 feet wide, terminated by a pointed end, the sides of which were 109 ft. 6 in. long, and met at an angle of 80°, making the extreme length 581 feet. The height of the quay was 6 feet to 9 feet above T. H. W. M., according to the situation of the jetty in the dock.

On the jetty a warehouse was built, 500 feet long and 80 feet wide, consisting of vaults and two floors, of nearly an acre in extent each. The outside space of 30 feet on each side to the edge of the quay was appropriated to railways and the temporary storeage of goods. Facilities for discharging and arranging goods were provided by hydraulic cranes; one capable of lifting 5 tons with a range of 31 feet being placed at the pointed end, and eight others, arranged in pairs, sweeping outwards from 21 feet to 23 feet, and capable of lifting 2 tons each, were placed at intervals on the sides of the warehouse. There were also turntables and sidings, for the purpose of collecting and distributing the waggons on the main line of railway leading from the docks.

The side walls were described as a combination of cast-iron piles, vertical brick inverts, and concrete, with a backing of clay.

The piles, which were T shaped in section, and 35 feet long, weighed about 1¾ ton each. They were driven to a depth of 28 feet below T. H. W. M., at intervals of 7 feet. Between them the brick inverts, which were 14 inches thick, were filled in; and behind this the concrete was carried for an average thickness of 3 ft. 6 in. The piles were connected to each other across the jetty by two tiers of tie-bars, 2 inches in diameter, and 12 feet apart; the upper one being placed 5 feet below the heads of the piles, and by means of them the piles were secured from being forced outwards, and could be adjusted in line. The bottom of the wall was commenced 1 foot below the bottom of the dock, and the wall itself was considerably strengthened at the pointed end, to enable it to bear the blows to which it was exposed, and as a foundation for the 5-ton crane. The top was finished off with a cast-iron capping and wood cill secured to the heads of the piles; and the upper surface of the jetty was ballasted, and some portions planked. As a precaution, the angle formed by the upright face with the floor of the dock was filled to some height with clay puddle, to prevent the passage of water under the wall.

The total cost of each jetty, exclusive of the warehouse and cranes, was £12,000, or £10 per foot run of the quay.

It was noticed that an incident which at first threw some doubt on the capability of the walls to resist the passage of water, was afterwards satisfactorily accounted for. It was explained that the floor of the vaults under the warehouses was about 2 feet 6 in. above the marsh level, and 6 feet below that of the water in the dock at T. H. W. M. When the water was first admitted it appeared in the vaults, and it was found necessary to remove it by means of drains. This, which was supposed at first to result from leakage either through or under the walls, was soon found from its containing iron to be water from the gravel, which in this district rose to within a short distance of the surface, and in this case gained access to the vaults by means of the concrete walls of the warehouse. The discharge from the drains was now very slight; the diminution being attributable to the consolidation of the ground against the walls, and to the silting up of the porous materials, by the rusty deposit found in the water. It was remarked in corroboration of this explanation, that quite recently the discharge from one jetty entirely ceased during the time that the level of the water in the gravel was kept down by pumping to get in the foundations of a new warehouse in the immediate vicinity, but was re-established shortly after the pumping was discontinued.

The casualties which occurred during the construction of the dock were fully described; these were comparatively few for a work of such importance.

The first, which was a fracture of the cast-iron shutting cill, arose from the subsidence of the ground under the heavy side walls being greater than that of the brick platform to which the shutting cill was bolted down. The side walls subsided about 1⅛ inch, and in consequence the cill was cracked near the centre. The defect was soon discovered and as speedily remedied, by bolting a plate of wrought-iron on the back of the cill. This accident pointed out the importance of allowing the side walls to settle before the holding-down bolts of the cill were finally tightened.

The next casualty occurred in the lock-chamber, where, without any premonitory symptoms of weakness, and almost simultaneously, both sides of the chamber between the upper and lower gates moved bodily forward,

Digitized by Google

pushing up the thick puddle towards the centre, bending and breaking the tie-bars behind, and dragging the tie-piles forward, fracturing several of them, whilst however the brick side walls of the gate platforms remained entirely uninjured. Very energetic measures were adopted for reinstating the walls. The old concrete was cleared away, the iron piling was driven 10 feet lower than previously, the sheet piles entering 5 feet into the clay; in which a solid concrete wall was commenced at a depth of about 5 feet, and was carried up for a height of 18 feet, with a thickness also of 18 feet, above which it was reduced to 10 feet in thickness, with counterforts projecting 6 feet, with a breadth of 6 feet, and at intervals of 10 feet, nearly to the top of the piles. On this mass of concrete a brick wall was built, 10 feet high, averaging 4 ft. 6 in. in thickness, with counterforts 3 feet square and at intervals corresponding with those below. The piles were secured to the concrete walls by means of iron rods passing through them to cast-iron plates, to which they were screwed up tight at the back. The clay puddle was removed from the bottom, and was replaced by a mass of concrete, with a top layer of Portland cement concrete 6 inches in thickness. The damage was completely repaired in three months, and no signs of weakness were subsequently perceived. This casualty was accounted for by the previous draining of the ground all around, due to the constant pumping during the progress of the works; and on the cessation of this process the water rising behind the walls occasioned additional pressure, which forced the sides inwards. That the failure resulted from this cause was demonstrated by the fact of the movement of the two sides being nearly simultaneous.

The next casualty which occurred was the fracture of two of the pivot castings of the lock gates. This was shown to have arisen from the binding of the brass socket upon the iron pivot, so that the pressure, instead of being distributed over the whole area of the step, was restricted to a comparatively small annular portion; thus the brass "seized" or adhered to the pivot to such an extent, that the gate, instead of working upon the pivot, turned upon the brass, and burst the sides of the box in the effort to free itself. At this period also the gates were leaky, in consequence of some of the joints not being tight, and the weight upon the pivot being much increased. The mischief was aggravated by hydraulic power being employed to open and shut the gates, and thus the undue resistance was not so soon perceived as if capstans worked by manual labour had been employed for a short time after the completion of the gates. This course was recommended as a prudent precaution in similar cases. The cause of the casualty being ascertained, the remedy was easy, and was speedily applied.

The last casualty was the splitting of the roller path, which was a direct and intelligible result of the previously mentioned leakage having rendered the gates so much heavier than the casting had been intended to bear. This was remedied by rendering the gates water-tight; and in putting down a new path the surface for the roller was made 7 inches wide instead of 4 inches, and no difficulty has since been experienced. These casualties were very fully detailed, as being perhaps more useful than any other part of the paper.

The latter portion of the paper was on some advantages of the form adopted for the Victoria (London) Dock Gates, with respect to economy of material and general arrangement.

The term cylindrical, or gates of continuous curvature, was adopted to distinguish them from those formed like a gothic arch, and was employed to denote that the outer or convex curves constituting both leaves were struck from one centre, or formed portions of one and the same circle. The inner boundary was formed in the same way, or not differing materially from it.

Before proceeding to compare this form of gate with that of straight gates meeting at an angle, it was stated that no advantage was claimed for the former in respect to the amount or direction of the strain brought on the lock walls, but in regard to the section of the gate itself, even in ordinary cases, there was believed to be considerable superiority.

A few preliminary remarks were then made on the strains to which these structures were exposed; that in the cylindrical gate a compressive strain was induced by the pressure of the water, which was uniform on every radial section in the same horizontal plane (though of course varying with the depth); while in the straight gates meeting at an angle there were two strains, first, a transverse strain caused by the pressure of the water, and similar to that on a girder uniformly loaded, and, secondly, a compressive strain, arising from the pressure of the other leaf on its extremity. The compressive strain on any horizontal section of the cylindrical gate was stated to be equal to the pressure on the unit of surface multiplied by the radius of curvature, as shown by Prof. Barlow (*vide* Trans. Inst. C. E. vol. i. p. 133). The important distinction between the two kinds of strain to which straight gates were exposed was pointed out by Mr. P. W. Barlow, M. Inst. C. E., in his paper on Lock Gates, at page 67 in the volume already cited.

Some examples were then given, showing that this compressive strain in the straight gate varied very considerably, according to the ratio of the height or versed sine to the span; and consequently the importance of providing sectional area to meet this, as well as the strain induced by the direct action of the water on the leaf itself. With regard to the distribution of this strain in the two skins, the problem was not capable of accurate solution, in consequence of several practical modifying circumstances, but it was thought sufficient for the purpose of comparison to assume the equal distribution, especially as that view was in favour of the straight gate.

Some examples were then given in detail, for the purpose of instituting a comparison between the weights of gates required for spanning the same opening with the same rise or versed sine when made in the cylindrical form, and also with straight leaves meeting at an angle. The results were shown in the following table:—

Ratio rise to span.	Vertical angle.	Transv. strain in centre.	Compres. strain due to op. leaf.	Straight Gate.		Cylindrical Gate.	
				Mean section.	Quantity of material.	Mean section.	Quantity of material.
1 to 10	157° 22′	69·32	102·0	29·6	1207	26·0	1066
9	154° 58′	69·94	92·3	28·4	1164	23·6	975
8	151° 26′	70·82	82·5	27·25	1123	21·25	885
7	148° 10′	72·08	72·9	26·25	1092	19·0	801
6	143° 8′	74·06	63·3	25·3	1069	16·66	715
5	136° 24′	77·32	53·8	24·8	1011	14·5	640
4	126° 52′	83·33	44·7	24·9	1117	12·5	580
3	112° 38′	96·27	36·0	26·0	1250	10·8	552
2·66	106° 16′	104·15	33·3	28·0	1400	10·4	558

Some remarks were then made on several other practical advantages arising from the cylindrical form, in utilising sectional area, avoiding to a great extent unequal thicknesses of plates, and rendering the operation of caulking more easy and efficient. At the same time certain objections were mentioned, and it was stated that additional cost would be incurred in the manufacture of the cylindrical gates; but it was thought notwithstanding that the following propositions were fairly established:—

1. That a lock gate of the cylindrical form could be made with about half the quantity of material required for a straight gate.
2. That with the same ratio of rise to span, a saving of from 11½ to 55 per cent. might be effected in the skins alone, and that a further saving might be made in the horizontal diaphragm.
3. That by this mode of construction great facilities were afforded for rendering the gates watertight, and greater certainty be attained in accomplishing this very desirable object.

GEORGE P. BIDDER, Esq., V.P., in the chair.

May 3.—The paper read was "*On the Tyne Docks at South Shields, and on the Mode adopted for Shipping Coals.*" By T. E. HARRISON, M. Inst. C.E.

These docks had been constructed on the banks of the river Tyne, at the upper end of South Shields, on a large area called Jarrow Slake, which was covered with water at spring tides to a depth of from 5 feet to 8 feet. The area so covered amounted to about 350 acres, and of this quantity 179 acres were now inclosed. The area of water in the dock as executed was 50 acres, the depth of water being 24 ft. 6 in. at an average spring tide. The entrance basin was 9½ acres in extent, with a depth of water of 25 feet for a width of 200 feet in the centre of the channel, gradually shoaling to the sides. One entrance had a width of 80 feet, and there was a lock 300 feet in length and 100 feet in width, with gates 60 feet in width; the cills in each case were laid 24 ft. 6 in. below high water of average spring tides—such spring tides having a lift of 14 ft. 6 in.

The total quantity of excavation in the docks was 1,783,452 cubic yards, and in forming the standage ground 281,305 cubic yards. The total quantity of masonry of all descriptions was 2,900,000 cubic feet. The cost up to the date of the opening for public traffic was £440,476. This sum included all the standage and railway approaches, the shipping jetties, the purchase of land, and all the dock-works, but it excluded parliamentary and other charges not engineering. The works were under the immediate superintendence of Mr. Robert Hodgson, as resident engineer; and the contract for their execution was let to Mr. James Gow.

The first point of engineering interest was the nature of the foundations. A series of careful borings showed, that though there was in places a strong stony clay resting on the coal measures, yet this clay was very partial, dipping suddenly away. Within a few yards of the clay-bed, borings were made to a depth in some places of 70 feet and upwards, through the mud or slake deposit, without getting a bottom; showing that not only the clay, but the coal measures, were gone. The original level of the ground was ascertained to be 10 feet below the lowest ebb of a spring tide at the present time, confirming the opinion that a general depression of the east coast had taken place.

The first operation in the construction of the works was to form a culvert, 5 feet in diameter, round the head of the dock area, to receive and carry off the upland waters. Dams were then formed of the materials from the excavations, consisting partly of clay and partly of slake, and after their completion the water was run off by sluices. Shortly after the first course of masonry of the foundations was laid for the north or 60-feet lock, the floor was observed to rise very regularly, about 3 inches

Digitized by Google

in the centre. A bore hole was then put down, when a strong feeder of water came away. The hole was therefore kept open during the progress of the works, and similar holes were made in other places. The flooring of the lock went back partially after the hole had been opened several days; and it was brought nearly to its original level by being weighted with stone.

In building a quay wall opposite the Jarrow Chemical Works, it was found that the slake would not bear the weight of the bank behind it, unless at a slope of 1 to 5. As so flat a slope was inadmissible, the plan adopted for overcoming the difficulty was by weighting the top with gravel, by which the toe of the slope was forced out. It was not until 150,000 tons of gravel had been deposited that the whole came to a state of rest. The slope was at present 1¼ to 1. It was pitched with stone, and rested at the bottom on a strong row of piles.

With a view of testing practically the sustaining power of the mud or slake, a bed of concrete 10 feet square was gradually loaded with iron, to the extent of 7 cwt. per superficial foot, without any settlement taking place; but as soon as that weight was exceeded the whole began to sink. The foundations of the timber jetties for the shipment of coals were therefore laid on a wide-spread base of concrete, with timber cill-pieces; care being taken not to exceed a weight of 5 cwt. per superficial foot. It was satisfactory to be able to state that there had not been the slightest appearance of settlement.

Immediately below the entrance to the tidal basin there was a canch of hard clay running out into the river. This had been entirely removed by dredging, and the flood and ebb tide now took their course as nearly as possible over the same channel, guided by the concave river wall. The latter was entirely constructed of creosoted timber, by means of one of Nasmyth's steam pile engines. A description was then given of this machine, which was so arranged that it formed its own roadway throughout; and it was remarked, that where there was a large amount of straightforward piling, or in cases of difficult driving, this machine was without an equal.

The dock gates were generally on the same plan as those of the Victoria (London) Docks. The only difference was that the Tyne Dock gates were curved both on plan and in section, the pivot of the heel-post being raised 3 ft. 6 in. above the level of the cill. There was thus less danger of anything lodging behind the heel-post, and the invert of the lock was carried right through from the end of the pointing cill. It involved however some large and rather intricate masonry, and necessitated great accuracy in fitting the doubly-curved wood cills to the doubly-curved masonry; but this had been successfully accomplished, and the cills were perfectly tight. One of the advantages in the use of wrought-iron for dock gates was that from their flotation the weight on the rollers might be adjusted at pleasure. The sluices were all made to work with brass against brass. The dock gates and sluices were arranged to be worked either by hand or by hydraulic power, the machinery for the purpose having been furnished by Sir W. G. Armstrong and Co.

The primary object of the construction of the Tyne Docks was to provide accommodation for the shipment of the large quantity of coals brought to South Shields, from the coal-fields of Durham and Northumberland, by the extensive system of railways belonging to the North Eastern Railway Company. The coal trade of the northern coal-fields had been gradually increasing for many years past; and in 1858 the quantity shipped at South Shields amounted to 1,203,524 tons, although the facilities were so limited that it was necessary to work night and day throughout the whole year. This was now wholly shipped at the Tyne Docks, and the work was generally done in fifteen hours.

A brief account was then given of the different methods of shipping coals used at the northern coal ports during the last forty-seven years. The system of "keels" was first described; and it was stated that it still existed to a limited extent both on the river Wear and on the river Tyne, in the case of those collieries not having direct railway communication to a place of shipment. Where the vessels could reach the shipping places, as at the Wall's End Colliery, the mode of shipment was by spouts, in general principle the same as those adopted at the Tyne Docks; but without for a long time any arrangement for allowing for the difference in the level of the tide and in the size of the vessel. The first innovation on the "spout" system took place in 1812, when a coal-drop was erected at Pelaw Main Spout, on the river Tyne, by Mr. B. Thompson, further improved by him in 1813, and since generally followed, with various modifications. The principle of all these drops was, that the loaded waggon in its descent raised a counterbalance weight; and when the coals were let out of the waggon, the counterbalance weight brought the waggon back to its previous position. The system of tubs fitted into "keels" in order to avoid the breakage of the coal was then alluded to, and the machinery by which they were transferred to the vessel was briefly described.

It was stated that after mature deliberation and careful examination of all the different plans, it was decided to adopt in the Tyne docks the system of shipping by spouts. The angle of inclination of the spouts was 50°, that having been found by experiment to be the angle at which coals would slide on smooth iron plates without rolling. In order to allow for the varying level of the ship's deck, which it was shown might amount under certain circumstances to 20 feet, arrangements were made to deliver the coals at four different levels. The coals were directed into any one of four divisions by the opening or shutting of trap doors, turning on hinges, and well balanced, so as to be easily moved. The spout was also raised or lowered in guides, and was operated by winches, the men standing on the level at which they worked when shipping coals. Traps were also provided for regulating the descent of the coals into the ship. In some cases the spouts were made to slide in a frame turning on a pivot, the object being to give a greater range into the ship's hold, particularly with screw colliers, and thus avoid the necessity of moving the ship. In practice the plan was to keep the spout nearly full, merely letting the coals slide sufficiently down to allow of the next waggon being teamed; so that although in the first filling of the spout, or on altering the level of the spout, the coal had a few feet to fall, yet this only applied to a small quantity of coal. Afterwards the whole mass slowly descended, and no further breakage took place.

Two jetties, on which there were twenty shipping places, were already at work. The shipping places were 100 feet apart from centre to centre, and were so arranged that the vessels overlapped each other. Arrangements were made so that the number of shipping places could be increased to fifty, as the trade required. In laying out the ground the saving of manual labour had been a primary consideration, and gravity had been called into operation to the utmost possible extent. The sidings into which the locomotive engines brought the waggons were on an inclination of 1 in 132. From these sidings the waggons were sorted by gravity into one or other of fourteen additional sidings, also on an inclination of 1 in 132, but at the curves and switches of 1 in 66. This sorting was effected by one man and one boy (who attended to the switches) for each jetty. When the waggons were wanted for shipment, they were brought out of the sidings, and descended by gravity, converging to one point, where there was a weighing machine; when passing over this machine at a rate not exceeding two miles an hour, the weights were easily taken. The lines then branched out again to the different spouts, the waggons being directed into their proper roads by switches, the working of which was attended to by one boy. There was a considerable amount of standage provided for each spout, and the length of single line of rails for each jetty was six miles. The standage was on inclinations varying from 1 in 32 to 1 in 100. Where the waggons descended from this standage to the spouts, the inclination varied from 1 in 20 to 1 in 87. The empty waggons were returned along two lines, one on each side of the jetty, having an inclination of 1 in 100. The impetus of the loaded waggons in descending carried them up this gradient, to or beyond the places where they were to be emptied, and when emptied gravity took them away. Experience had shown that twelve chaldron waggons, or six 8-ton waggons, might be taken down at a time. They were all run past the hopper, then dropped back by gravity, and were emptied three or two at a time, as they passed over the spout, without being uncoupled. Great expedition resulted from this arrangement; and on the day of the opening a screw steamer entered the docks, received on board 420 tons of coal in fifty-five minutes, and immediately went to sea.

In order to ship the quantity of coals now transferred to and being shipped in the Tyne Docks, there were employed last year at South Shields thirty-four horses and four pilot engines, and the work was carried on throughout the whole twenty-four hours. Under the present arrangement not a single horse was employed, and only two pilot engines, and the work was done generally in fifteen hours. At present there was rather a deficiency of standage for light waggons, but this was in course of remedy, and when completed no engine would be necessary. The cost of labour for carrying the coal along the jetty, a distance of 1050 yards, for the shipment, and for returning the empty waggons to the point where the engine took them up, was about seven-sixteenths of a penny per ton.

SUBMARINE TELEGRAPHS.

The great cost of gutta-percha—about 2*s.* 6*d.* per lb.—coupled with its now well-known deficiencies as an insulator, has roused the chemical world into efforts to discover some substitute which, while possessing all non-electrical and mechanical essentials, will at the same time relieve telegraph companies from the immense outlay now required for coating their wires with gutta-percha. Several experiments have been made with this object. Messrs. Silver and Co. have been foremost among the experimentalists, but instead of devising a new substance, resolved to trust the well-known properties of india-rubber, and with this view have coated several miles of wire with a double layer of that material laid on in spiral folds or bands, with their edges closely joined so as to be perfectly impervious to water at any pressure. Even at the present high price of india-rubber, wires can be thus coated at very little more than half the price charged for gutta-percha. The cost, however, is one of the least advantages of the material. India-rubber is almost as incompressible as water, and compared with gutta-percha requires a very high degree of heat to melt it, boiling water having no effect upon it whatever. Some lengths of the wire thus coated at Messrs. Silver's works have been

Digitized by Google

subjected in a hydraulic machine, for a considerable time, to a pressure of 7½ tons on the circular inch, and when tested, while still exposed to this pressure, the most sensitive of Mr. Henley's galvanometers showed the insulation perfect. An attempt to apply a higher rate of pressure than this terminated in the bursting of the hydraulic cylinder. When it is recollected that 5 tons pressure to the square inch crushes granite, it will be seen that a more complete test of the value of india-rubber as an insulator to resist pressure could hardly have been devised. The importance of its possessing this quality is far greater than would at first sight be supposed. A pressure of 7½ tons to the inch is equal to the pressure caused by the weight of water at a depth of eight miles. The greatest depth at which the Atlantic cable was submerged was three miles, and the weight of this mass of water upon the rope at the bottom of the sea was about 2½ tons. Gutta-percha at such a pressure is reduced to less than half its bulk. To this apparently insignificant fact it is possibly owing that the cable is now useless, for it follows, that when the core of the rope shrank to half its original diameter the outside wires stretched in proportion, while the gutta-percha could not but tear under the strain, and leave the conductor exposed in many places. The advantage, therefore, of india-rubber over gutta-percha in this respect is apparent, since it exactly reverses the unfavourable conditions of the latter, being incompressible and highly elastic. During the course of the experiments a considerable length of wire insulated with two coats of india-rubber was immersed in a large boiler of boiling water. Though the external part of the covering was boiled almost white, the insulation remained perfect. A similar length of wire coated with gutta-percha of the same thickness as the india-rubber was, of course, destroyed as a non-conductor immediately on its immersion, as gutta-percha melts easily at 100 degrees. It is true that submarine cables when laid are not required to encounter a heat of 212 degrees, but it is well known that while in process of manufacture, and especially when packed in ships' holds for the purpose of being submerged, they are often exposed to an amount of heat to which gutta-percha yields. This melting at a low temperature, together with the wire being badly centred at the Gutta Percha Company's Works, was a source of incessant anxiety to those on board the Agamemnon and Niagara during the expedition of last summer. The deck coils, from being exposed to the sun, were more liable than others to this danger, and some portions of them had to be cut out in consequence of the copper wire having pushed through the soft gutta-percha. On both these important points, therefore, the introduction of india-rubber would be of immense benefit, and it is believed that if it were clearly shown that the supply of material might be depended on, and the rate at which the wires could be covered would be equal to the demand, it would soon entirely supersede gutta-percha as a means of insulation. Experiments are also being carried out by another firm for the purpose of devising an insulator from a combination of india-rubber and shellac. These tests, however, are not sufficiently advanced to be made public, though the results up to the present give promise of success. When such efforts are making on all sides, it seems improbable that the use of a faulty and expensive insulator like gutta-percha will be much longer continued.—*Times.*

NEW CHURCH OF ALL SAINTS, MARGARET STREET.

THIS magnificent structure, the completion of which was, for want of funds, delayed for several years, has at last been finished, and was consecrated and opened on Saturday the 28th inst.

The site is a square of about 110 feet, occupied by the church and two houses; the church and houses surround on three sides a court yard which is open on the fourth side to the street. The two blocks of houses are connected by a low brick and stone screen with an effective archway in centre. The wall is surmounted by an arcade of open ironwork. The houses and screen form the entire elevation to the line of street. The church, situated at the back of these houses, occupies the whole length and remaining width of the ground behind them, from east to west, and parallel with the street. The church consists of nave and chancel, with aisles (north and south) to both nave and chancel, and of tower and vestry. The tower is at the west end of the south aisle and is embedded in its lower stage between the western house and the south aisle. The lower story serves as the baptistery. The whole of the church is carried on vaults of massive brickwork, upon the arches of which the concrete floor of the church is laid. There are no windows in the north wall of the church nor east end of chancel; owing to the confined nature of the site they could not be obtained, which has called forth peculiar treatment of the wall spaces. The architect has admirably turned the opportunity to account, and produced an effect most pleasing and novel.

The materials of the walls of the buildings generally are of red and black bricks and stone; internally, red and black bricks of a superior kind (made by Minton, of Stoke, Staffordshire) are freely used; Caen stone, marbles, and alabaster, in bands and mosaic, granite and other select stones, are used constructionally. The stonework internally is to a great extent decorated with inlaid patterns in dark cements. The marbles are chiefly of English production; the alabaster is from Derbyshire. The nave arches are of Caen stone, boldly moulded, supported by polished Peterhead granite clustered columns standing on black marble plinths. The capitals are of alabaster, carved in a masterly style, and of excellent design. A fine well moulded equilateral arch of alabaster, springing from a detached marble column on each side, divides the nave and chancel. The chancel is in its length divided into two bays, and is vaulted with chalk and alabaster; its western bays are each occupied by a traceried arch, opening into the chancel aisles. The heads of the arches contain tracery supported by circular columns of Cornish Serpentine with carved caps of statuary marble. The lower portion of the opening is filled up with an elegant brass and iron screen and gates. The eastern bays together with the east wall are arcaded in three heights; the whole arcading and wall space, sculptured cornices, and ribs of vaulting being entirely of alabaster, interspersed with Caen stone inlaid. The upper portion of north and south walls is occupied by tracery windows, filling up the triangular space formed by vaulting. The vaulting is enriched with inlays, gilding, and characteristic devices in colour. The arcade of east wall contains frescoes, by Dyce, representing in its two middle compartments, the Virgin and Infant Saviour, and the Crucifixion; six niches on each side contain the Apostles; surmounting them, and occupying the triangular upper space of wall, is a representation of Our Lord enthroned, surrounded by saints and emblamatic figures. All the figures are well designed and beautifully painted. The arcading of side walls is filled in with diapering in gold and colour. The nave and aisle roofs are of timber framing, with coloured enrichment. The rafters are all exposed, and ceiled between. The principals, purlins, and wall plates of nave roof are double, and are connected by rows of quatrefoils. The nave has a well proportioned arcaded clerestory, every fourth space being a blank to be filled with frescoes. Each of the other divisions of the arcade contains a two-light tracery window, from which the light for the interior is principally derived. The north wall of aisle is formed into panels by bands of incised stone, and will eventually be enriched with frescoes. The floor of the nave and aisles is laid with Minton's plain red and black tiles arranged in patterns, and divided longitudinally and diagonally by narrow stone bands; encaustic tiles are introduced at the junctions of the tile bands. The floor of chancel and beneath the tower is laid with various marbles intermixed with encaustic tiles.

A low screen separates the chancel from nave: the body of it is of alabaster, arcaded, panelled, and richly carved; the base, coping, and shafts are of various marbles. Brass gates of good design occupy the centre of the screen. The pulpit and font are of sculptured marbles of various tints. The metal-work in the church consists of brass gates in the chancel screen, and the side screens and gates dividing the chancel from its aisles. These screens are surmounted by rows of gas burners. The oak pyramidal cover of the font is also largely decorated with metal-work, and a brass lectern stands in the middle of the chancel. In the nave brass gas brackets of simple design are attached to the aisle-side of the columns. The metal-work was executed by Potter, from designs by the architect. The church is heated by hot water. The organ (constructed by Hill) is divided into two parts, and stands in the two chancel aisles; the two parts being connected by trackers beneath in the vaults.

The clerestory windows of nave and chancel are fitted with elegant bright-toned stained glass, designed by the architect. The west and south windows contain most unsuitable stained glass by Mr. Gerente, who, we believe, was commissioned by Mr. Hope. The chancel stalls are of oak and walnut, elaborately carved. The altar is of moulded and carved wood, and is surmounted by an alabaster super-altar, enriched with quatrefoils. An elegant metal cross is fixed immediately above it on the east wall.

Digitized by Google

The floor-space of the church is perfectly clear; chairs only will be used by the congregation. The mouldings and proportions of the work generally are bold and large, so as to give to the building an appearance of size which its actual dimensions would fail to impart.

The site was purchased by Mr. Beresford Hope, M.P. Mr. Henry Tritton, of Portland-place, we understand, provided the largest proportion of the building funds. Other subscriptions to it, we believe, have been comparatively small.

This building must not be compared with some of similar character which of late years have been erected by architects who have followed in the path struck out by Mr. Butterfield; for when this building was founded it stood alone as an example of revived principles of Gothic art adapted to modern requirements. It was intended to be truly a town church, built of materials of every-day use, produced in our own locality and country, and exhibiting the advantage of the truthful system of constructive decoration. The style of architecture adopted by Mr. Butterfield is the Early Decorated, in detail partaking of that exhibited by the ancient examples of France and Italy, but treated with considerable freedom and originality. It is but just that the author of this building should be placed in his true position as the pioneer and founder of the new school of Gothic art. Through the unfortunate stoppage of the works for a long period, other structures founded on the same principles were erected in the meantime, but from the similarity of treatment and peculiarities of detail which they possess, we must say that the authors are greatly indebted to the architect of All Saints' Church for their first principles.

ASSOCIATIONS FOR THE PROMOTION OF ART.

By G. F. Mulvaney, R.H.A.*

The author, after stating that he did not intend discussing any of the various phases or principles of art, but rather to draw attention to the condition of art in Ireland,—how it may be promoted, and the latent genius of the country be developed, said—

"It must be admitted that the state of art in Ireland is far from creditable to the country. It cannot be asserted that this is attributable to any deficiency of natural genius, or to any want of industry and zeal on the part of artists themselves. It results mainly, if not solely, from the want of public encouragement,—of that demand which has in all ages and in all countries led to the fullest development of human ingenuity and skill. The most frequent argument raised in defence of such a state of art-abeyance is, that we have not wealth enough for its adequate encouragement. The argument is unfortunately not without weight as regards individual patronage; but given its fullest weight, it is an argument *à fortiori* in favour of the associative principle which does so much for art in more wealthy communities. Perhaps it would be more candid to admit that taste, as a diffused social element—rather than wealth—is wanting. To generate and cultivate this public taste must be the first aim of all who desire to promote art in Ireland, and it is the chief aim of all art associations. Education of artists and of the public by schools and exhibitions are the functions of some; while others seek by the purchase and dissemination of the works of living artists to reward merit and stimulate taste by facilitating the possession of good works of art.

I propose to draw your attention principally to these latter institutions, but I cannot in the interest of the associative principle, especially within these walls, omit to pay my tribute of grateful admiration to the parent association for the promotion of the fine and useful arts in these countries. The Royal Dublin Society, established for the advancement of husbandry and the useful arts, promptly recognised the value of the fine arts in connection with industry. The principle so asserted by the establishment of its schools more than a century past, is now the recognised principle of government schools of design. The Society's schools rapidly acquired an importance not perhaps at first designed. Under the auspices of this Society, those wonderful achievements of ancient art—those marvellous embodiments of perfect form in almost breathing marble, the sculptured gods of classic Greece—became known in this remote island, awoke the artist's spirit to a new sense of beauty, and led rapidly to a new development of power.

Artists as they multiplied naturally sought strength in association; but beyond their influence in education and their efforts to maintain public exhibitions, I do not regard societies of artists as, strictly speaking, associations for the encouragement of art. They are producers, not patrons: they seek to cultivate art,—they are valuable rallying centres of professional union and distinction. It is their duty and their aim to raise the standard of public taste; but they are themselves dependent for existence and success upon an appreciative public. When incorporated by charter or royal sanction on the continent they are subsidised by the state. In these countries they are mainly dependent on the revenue from annual exhibitions: when these are prosperous, as in London and Edinburgh, the royal academies prosper, and acquire influence and power of effecting public good. The Royal Academy of London is perhaps the wealthiest association of artists in the world. It enjoys a revenue of £6000 or £7000 per annum from its exhibitions: and after maintaining its schools and establishment, and devoting much of its funds to charitable support of distressed artists and their families, it has amassed a large fund. The Scottish Academy has from similar sources of success derived a large income, and has made a noble use of it, by accumulating a fund for charitable relief, and the acquisition of a valuable collection of pictures at a cost of upwards of £15,000, which is now deposited in the National Gallery of Scotland. The Royal Hibernian Academy is unhappily, as regards worldly prosperity, but too true a reflex of the want of encouragement of art in the country.

Other associations may be referred to, such as the British and the Royal Irish Institutions, designed to afford objects of study to the young artist, and to cultivate public taste by the exhibition from year to year of works by the ancient masters, the property of private individuals. The latter named institution had but a brief existence, but it has found after the lapse of years a successor in the Irish Institution, established in 1853, with the ultimate aim of the formation of a National Gallery. The building now in course of erection in Leinster Lawn, to which the Dargan Testimonial fund has been devoted, combined with parliamentary grants, is the best evidence of the work done by the Institution, and assures to Ireland its long-desired National Gallery.

From the period however when the Dublin Society established its schools—when Barry and Barrett first won distinction, and carried off their fifty-pound prizes—to the present, the history of art in Ireland, with some fluctuations, has been the same: upspringing genius—well-directed philanthropic efforts to facilitate education—honour and reward to the student—struggles, difficulties, and non-appreciation for the artist. Hence it arose that so many distinguished Irish artists have followed Barry and Barrett to swell the fame of the British school, while many whose natural gifts and educated powers were at least equal to those of the emigrants, have remained at home—forced too often to devote talents calculated for higher development, to the mere drudgery of art.

I am far from undervaluing what has been done for the promotion of art in Ireland by the education of artists, or the cultivation of public taste; on the contrary, I honour those who have persevered through all difficulties in the good cause, and I rejoice that we may regard our educational facilities as being nearly placed on an efficient basis. But what I wish particularly to enforce is, that in point of national economy all those energies are without their proper return, if we do not find means to secure prosperity to the artist as well as education to the student. The developed intellect, skill, and productive power of a country are, even in an economic point of view, amongst its acknowledged elements of wealth. I need not, therefore, dwell on the importance of developing a national school of art—of keeping our gifted men at home, instead of forcing them to bring their talents and wealth-producing powers elsewhere. It will be better to show how this public good can be achieved. Example is better than precept or argument, and fortunately an example is found in the progress of art in Scotland.

Twenty-five years ago, the state of art in Scotland was not dissimilar to its present state in Ireland. There was perhaps more private patronage of art, but the public interest in its progress or demand for its productions was small indeed. The Royal Association for the promotion of Fine Arts in Scotland was established, I believe, in 1834. It was the first effort to introduce into these countries the German system of *kunst-vereine*, or art-unions. It has been signally successful in its operations. In its first year the funds subscribed did not exceed £700 or £800; its

* Paper read before the Royal Dublin Society.

Digitized by Google

average income now is about £5000 per annum. Not only has this association evoked a Scottish school of art, to do which was its first aim by the purchase of resident Scottish artists' works, but it has expanded its operations to the purchase of works of art without reference to the country of their production.

Strong objections were raised to the system of art-unions at the period of their introduction. It was said that they were calculated to interfere with private purchase of works of art, which, as the result of discriminating taste, and the legitimate expression of demand, was morally and economically the true encouragement to art. This objection was strongly urged by artists themselves; but experience has shown that it was not valid, and art-unions so far from diminishing, have considerably stimulated and increased both private and state patronage. I cannot better illustrate the force of these early objections and the power of successful experience in dispelling illusions, than by a short quotation from a speech made by Mr. Harvey, a distinguished member of the Royal Scottish Academy, at a dinner given by the committee and members of the Edinburgh Association in 1846. Mr. Harvey said:—'When the Royal Association for the promotion of art in Scotland was formed, rather more than twenty years ago, I at that time felt it my duty to be one of its resolute opposers, thinking it likely that the purposes of art would be better served by such works as might be produced being purchased by private parties in the usual way, rather than by funds acquired by public subscription, and the subsequent disposal of the paintings by lot. My friend, Mr. Glassford Bell, who was the great promoter of the scheme at the time, kindly said he would meet my opposition by the purchase of my paintings, should I produce anything which the association might consider worthy of buying; and accordingly I had an offer made to me in the ordinary way for one of my works shortly after. This offer, to be consistent, I declined, and I have the painting in my possession still. Since that time, however, I have seen fit to alter my opinion on this subject. In fact, when I call to mind that in, I think, either the second or third year of the Academy's existence, the entire sum received for works of art sold during the period of the annual exhibition was, if my recollection serves me rightly, only thirty-five guineas—one painting having been bought by the present Lord Justice Clerk, then Dean of Faculty, for thirty guineas, and one by some person else for five—it was evident that in this state of things something required to be done one way or another.'

This candid admission on the part of Mr. Harvey speaks volumes for the cause of such associations as we are now considering. In fact, such was the success of the Edinburgh Association, and so much was the demand and love for art increased in Scotland, that in 1842 the Glasgow Art Union was established. The success of this latter institution, at least as to amount of funds, is unparalleled in the brief history of art-unions. Of course the annual amount varies; but in 1856 it exceeded £20,000; and in the last report of the council of the Scottish Academy it is stated —such was the competition between art-union committees and private purchasers—that, on the opening day of the exhibition of 1858, nearly £5000 were expended in purchases in the gallery. A happy contrast, certainly, to the season referred to by Mr. Harvey, when the total amount of purchases was 35 guineas.

When the Art Union of London was established in 1837, there was no lack of purchasers, as the numerous and prosperous art exhibitions of that metropolis testified. However, beyond the enjoyment which those exhibitions afforded, the luxury, the home enjoyment of art was confined to the wealthier classes. So little were the purposes of art-unions understood, or so coldly was their interference with private purchasers regarded, that in the first year of the London Art Union, the subscriptions only amounted to £489 6s. The great middle classes, however, soon recognised the importance of the institution, and the total subscription for 22 years amounted to £238,932. The beneficial results of so large an expenditure, in addition to the undiminished amount of private purchase, must be obvious to every one. Some object to it as an artificial stimulus calculated to produce a superabundant mediocrity. I cannot regard it in any such light; for mediocrity in art will only be tolerated by mediocre taste, and the constant diffusion of good works of art through means of art-unions—the increased stimulus to good local exhibitions throughout the country—the very excitement about art so caused, must lead to improved taste. The works of the first-rate artists are never in the market for art-union purchase; not because those societies do not occasionally give high prices, but because those artists are pre-engaged often for years by private individuals. Through all these means a public opinion has been created, recognising the social value of art, and the importance of its highest development, which has stimulated the state—ever slow to move until it feels the pressure from without—to expenditure in the patronage of the higher branches of painting and sculpture, as well as to a gradually expanding system of education in art by schools and public galleries. Nor must we overlook another important fact in connection with such associations: it is not the wealth of particular localities that is represented in the large annual incomes of the London, the Edinburgh, or Glasgow associations. They draw their resources from all countries, and especially from our vast and increasing colonies, while it must be observed that the benefits of the expenditure is mainly confined to England and Scotland. From Ireland alone these three art-unions in 1858 drew upwards of 1150 guineas. The committee of the Glasgow Art Union remark in their last report, as a reason for not being more exclusively purchasers of Scottish artists' works, 'that a comparatively small amount of their subscriptions are obtained in Scotland.' Surely for us these are suggestive facts.

I have drawn your attention in the first instance to these institutions in Scotland, on account of the priority of their establishment, and because there exists a greater analogy between the circumstances of this country and that, than between those of Ireland and England. I would also say that the analogy was illustrated forcibly by the brief experience we had in Ireland of a prosperous art union. A gleam of promise—our national sunburst—shed its influence on art and art institutions. The exhibitions of the Royal Hibernian Academy expanded in size, interest and merit, and a consequent rapid improvement took place in the exhibition receipts. The energies of resident artists were awakened, and their ambition aroused. It was, unfortunately, a brief success, but it was enough to convince any thinking man, that in the associative system of encouragement lay the best hope of developing the latent talent of this country. I think too much stress is laid upon the failure of our first Art Union. It would be far better to regard the very large amount of success it achieved, as showing what can be done by well-directed energy. There may have been errors in the system, or improvidence in the management, which left the institution unprepared for the fearful ordeal through which this country had suddenly to pass; but, taught by experience, a system more calculated for permanence can be devised, and there is nothing in the present position of Ireland or its prospects to forbid the hope of resuscitating art, and establishing a school worthy of the country and 'racy of the soil.'"

THE OPERA FLORAL ARCADE, COVENT GARDEN.

When completed this building will be among the handsomest markets of its kind in the world, and an important addition to the ornamental edifices in London. The Arcade is now in rapid course of construction in the form of a lofty glass and iron edifice of striking and elegant proportions.

The ground plan and shape of the building may be best described as resembling the letter L; the handsomest and principal entrance being by the side of the Italian Opera, at the end of the longer arm of the letter, while the other opens upon Covent-garden Market, by the side of the piazza, at the end of the shorter arm. Over the space formed by the junction of the two arcades, at right angles, will be a lofty dome,—the first time that ever anything of the kind has been attempted in glass and iron only. The extreme length of the Arcade, from the Bow-street entrance to the west wall, will be 228 feet; and the short arm, from Covent-garden to the theatre wall, 100 feet. The width of both parts of the building meeting at the dome is 75 feet, of which the lofty semicircular arched nave occupies 50 feet, with two side aisles between the main columns and the walls, each nearly 13 feet wide. The springing of the arches for the roof is 29 feet from the ground, and as to the top of the arch is 57 feet, the roof is almost a perfect semicircle. The dome, when completed, will likewise be almost a hemisphere, 50 feet in diameter and about 25 feet high, making the total height to the ornamental lantern which will surmount it a little over 90 feet.

The great fault of all our glass and iron structures has been their deficiency in anything like ornamental details. Artists appear to have had nothing to do with them. From this great fault the Floral Arcade has been redeemed by Mr. E. Barry, the architect.

Digitized by Google

The Bow-street entrance is handsome and simple. The doorways are deeply recessed, so as entirely to do away with the flat, boxy, hard appearance which the entrances to such buildings have hitherto possessed. The raised iron arches which give admission to the interior also aid this effect considerably.

The radii of the arched roof seen on the outside are ornamented, and seem to spread out like an elaborate fan; and the curve of the roof over the entrance is surmounted with a kind of corona of elaborate cast-iron work. Glass and iron buildings are of course light in their construction, and this peculiarity, with the ornamental features mentioned, is particularly noticeable in the Floral Arcade. The iron columns supporting the nave roof are graceful looking, and instead of being, as is usually the case, mere iron cylinders, rough and unadorned as lamp-posts, they are all cast of an exceedingly handsome pattern, with rich capitals, which are perforated in order to ventilate the basement story beneath the market, with which the columns communicate. All round the interior at the springing of the arches is an elaborate cast-iron moulding of bold and rich design, which is hereafter to be gilt, when its effect will be exceedingly beautiful. The aisles are nearly 13 feet wide and about 30 high, the theatre wall forming the side of the north aisle, and the wall of the Arcade that of the south. As the theatre wall is pierced with recessed windows, the corresponding wall on the south side will be of the same kind. The arches which carry the roof of the nave are trellised, and apparently of the very lightest possible construction. Yet, light as they are in appearance, they are immensely strong in fact, and have all been tested with a strain far above anything that can ever come upon them, as they have nothing but themselves to support. Between the arched ribs transverse bars of "deck" iron, T-shaped, at intervals of about 6 feet apart, stretch along the whole length of each arcade, and are riveted to the arched principals in such a manner as to give to the whole roof the rigidity of one piece. The dome will be composed of twenty-two ribs, braced round with wrought-iron supports. The ribs form a quarter of a circle, all resting upon an iron collar in the centre, which will carry the lantern. The Covent-garden entrance continues the public way of the Piazza through its front by a roofed glass and iron gallery 50 feet long by 25 broad. The basement under the floor of the Arcade forms one of the most extensive cellars excavated anywhere out of the docks. It has the same immense area as the building above it, and is no less than 16 feet high; 10-inch cast-iron columns, forty-eight in number, carry the floor of the Arcade upon powerful wrought-iron girders equal to fifty times the weight that can ever come upon them. The floor of the Arcade is fireproof, formed of tiled arches between the girders, and over these an ordinary planking floor is laid for warmth and convenience. When the Arcade is complete it will be decorated in white and gold, a style which will admirably suit its light and elegant details. Through all parts of the structure pass hot-water pipes for keeping up the temperature during the winter, and gas is also laid on, so that the interior can be lighted up for night fêtes in an instant. This arcade is intended simply as a flower-market, to bring together in one building especially adapted for the purpose the immense trade which is now scattered all over the suburbs of London, in the hothouses and grounds of the great florists and nurserymen.

PRINCESS'S THEATRE.

THE splendid series of Shakespearean "revivals" which have been in course of production at this theatre for several years, and which have constituted so marked an epoch in theatrical art, is now about to be terminated, owing to the retirement of the manager from the scene of his arduous exertions. As a closing reproduction, well fitted to display the peculiar talents of Mr. C. Kean, and the resources of his establishment, the play of *Henry V.* has been judiciously selected. The interest chiefly centres in the monarch himself, into whose mouth our great bard has put some of the most stirring speeches he ever penned; the rest of the play is unequal, depending on the various accessories, and the abilities of the different impersonators; nevertheless it has always held a high place as a composition, and been a favourite with most of our good actors.

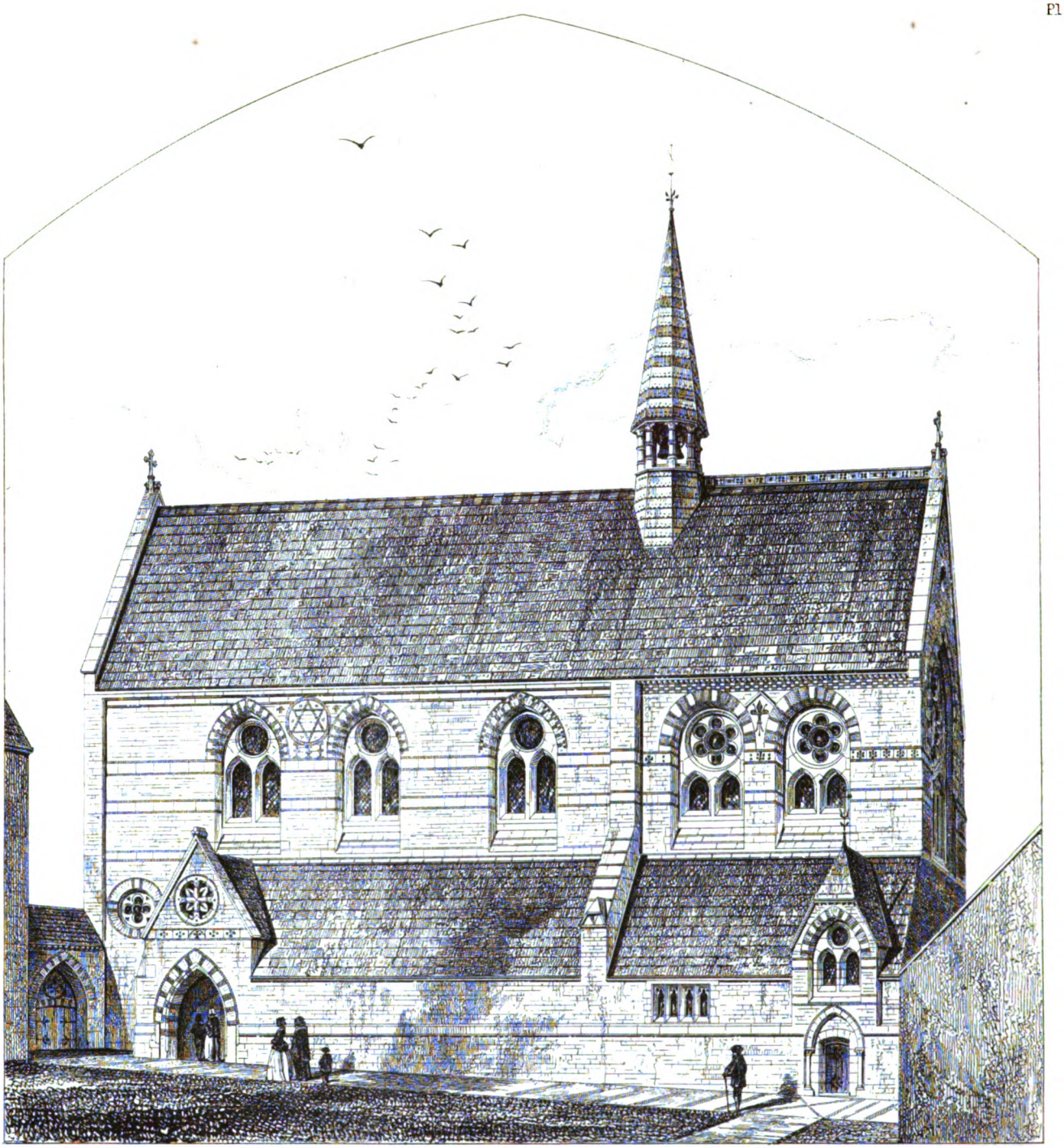
It will be unnecessary to observe that in the production of this play Mr. Kean in no way falls short of his previous successes, and far outshines all his predecessors in the *mise en scène*—a department of which he is so thoroughly a master; while Mrs. Kean, by a happy idea, exchanges the traditional figure of Time—under the semblance of an aged man, who had hitherto represented the "Chorus"—for that of Clio, the muse of History. This Chorus, or Clio, at the commencement of each act, in a kind of descriptive poetry, connects and explains the action as it proceeds, but Shakespeare has not in this instance assigned, as in *Pericles* and the *Winter's Tale*, a distinctive individuality to the character. In the "revival" of the latter play we took occasion to remark at some length on its special features; the present occasion does not call for such analytical criticism; Henry V. at the Princess's is rather to be seen than described: it is a splendid pageant, a complete study of costume and decorations, of which the variety and splendour can scarcely be imagined; and there is the more satisfaction in their contemplation since we are assured that they are, as nearly as can be ascertained, in strict conformity with the usages of the period. Bearing in mind this adherence to consistency observable throughout, we can only account for the declamations of the "Chorus" being made from a *classic* peristyle of the Ionic order, because in the present acceptation it is represented by a classic muse.

Some of the scenes are well deserving of notice. One of these shows "The painted chamber at Westminster" (to which frequent reference is made in history as the room in which Henry V. held his councils), and where the frescoes on the walls, and the superb throne powdered with the letter S, form conspicuous objects.—"A scene in Eastcheap" affords an opportunity for some characteristic groupings of picturesque old timber houses. "The council chamber in Southampton Castle," a venerable Norman interior, with rich tapestry round the walls. "The room in the French king's palace," in act ii., though showy, is not architecturally so good, but the landscape scenes of a "View in Picardy," and the "French camp," are triumphs of artistic skill. A great aim at effect has been successfully achieved in the realisation of the conflicting scenes at the seige of Harfleur, where the king's impassioned address tells with wondrous power on his dispirited army. But the *piece de resistance* is the "Historical Episode" introduced between the fourth and fifth act, and which is supposed to exhibit the reception of King Henry, on returning to his capital after the French expedition. It would be impossible to include the manifold incidents of the royal progress in one scene; neither could all the sites on which they actually took place be successively exhibited. The most prominent are, therefore, selected, and thrown into one locality—the approach to Old London-bridge. It will be recollected that, in the revival of Richard II. a similar interpolation was ventured on, and with so much success as to warrant this second attempt. In the last act there is a charming scene—"France in the neighbourhood of Troyes;" also a carefully rendered "Interior of the cathedral" at the same place. The high metal screen and grille work, in particular, are very accurately given.

Burford's Panorama Galleries, Leicester-square.—In China, India, and Switzerland are laid the scenes of the three panoramas now on view at this favourite place of resort. The former is the latest addition, showing "Canton after its bombardment." It has been painted, we understand, from photographs taken by the Royal Engineers; but if the visitor enter with grandiose expectations as to the probable beauty of one of the chief cities of the celestial empire they will assuredly be dispelled. There is positively nothing attractive nor even pleasing in the look of the buildings, nor is the surrounding landscape particularly enchanting. The dwellings are mean in appearance; they are also for the most part small, detached, and of the simplest and most monotonous character, while none of the streets exceed about 16 feet in width,—if we are credibly informed. Lucknow presents a totally different scene. Here the influence of civilisation and luxury are apparent: the buildings are numerous, large, and handsome; the oft-repeated dome, richly gilded, glitters in the sky; the parapet and balustrade are intermingled with Eastern features in a picturesque and fanciful manner. The roofs of the houses are uniformly flat, and are covered with a kind of cement. The church, a would-be Gothic edifice, has low pitched gables, which are thorough shams, the real roof being, like the houses, flat. Two bridges span the river, and the abundantly luxuriant foliage forms a refreshing feature in a landscape which has well been termed "the garden of India." The "Righi Culm" is well known to travellers as one of the special landmarks of Switzerland.

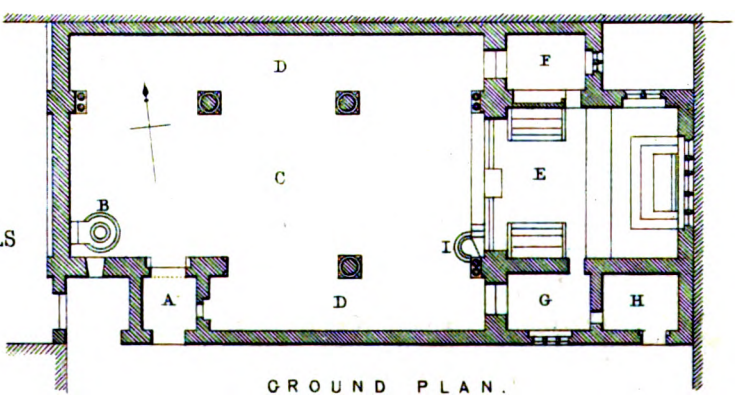
Digitized by Google

Digitized by Google



CHURCH OF

ST MICHAEL AND ALL ANGELS



GROUND PLAN.

BRIGHTON.

G. F. BODLEY, ARCHT

Digitized by Google

J.R.Johbins.

NEW CHURCH OF ST. MICHAEL AND ALL ANGELS, BRIGHTON.

(With an Engraving.)

THIS church, of which we give an exterior view from the south-east, is about to be built at Brighton. The material employed will be brick for the walls both internally and externally. The arches, windows, doorways, &c. will be of Caen or Bath stone. The floor will be a paved one throughout. Moveable seats and chairs will be provided in the nave, and stalls fixed in the chancel. The principal dimensions will be—nave 23 ft. 6 in. wide and 66 feet long; aisles 9 feet wide; chancel 23 ft. 6 in. by 31 ft. 6 in. The height to ridge will be about 65 feet. The cost will be about £4000 for the fabric, and some further decorations will be added. The architect is Mr. G. F. Bodley, of Wimpole-street, London.

References to Ground Plan.

A. Porch.
B. Font.
C. Nave.
D. D. Aisles
E. Chancel.
F. Chancel aisle.
G. Sacristy.
H. Vestry.
I. Pulpit.

THE INSTITUTE OF BRITISH ARCHITECTS.

THE report just printed of the proceedings of the Institute during the past session is, on the whole, of a congratulatory character. Allusion is naturally made to their continued occupancy of the rooms in Grosvenor-street instead of having removed to their new premises in Conduit-street; and this is explained by the protracted difficulties which the Architectural Union met with even after the essential preliminaries had been gone through, in appropriating space, and effecting the alterations required by the several Architectural Societies which had to be located under the same roof. The accession of eight Fellows and ten Associates to the previous list of Members is notified,—the Institute now consisting of 154 Fellows, 139 Associates, 13 Honorary Fellows, 17 Honorary Members, 80 Honorary and Corresponding Members, and 13 Contributing Visitors. The losses to the Institute, occasioned by death, are next recorded, amounting in number to six.

To the subject of the Architectural Union Company reference is made at some length in the body of the report, and we transfer the remarks in full.

"The munificent example set by our noble President in presenting twenty shares in the Architectural Union Company to the Institute, has been followed by our respected Fellow, Mr. Tite, M.P., who has given ten shares, and by Mr. St. Aubyn, Fellow, who has just presented five shares, in the same company. Should these donations be increased by other friends and members, the prospect of the Institute becoming, in a great measure, its own landlord would be far from Utopian. To those who may not think fit to present shares, it may perhaps be permitted to suggest the establishment of an auxiliary fund, on the present occasion of removing to new apartments, in order to meet the heavy demands on the stock of the Institute, by which the annual income will be lessened, while an increase will take place in the rent. (Since this Report was read, Mr. T. L. Donaldson, Fellow, has presented the sum of 25*l.* to the 'Removal,' and the like sum to the 'Travelling' Fund.) The rooms in Conduit-street are fully described in last year's Report: but it may be again mentioned, that on four evenings during the session the Institute will have the right of using the whole suite of spacious galleries at the back of the main building for conversazioni and similar purposes. The council believe that by judicious arrangements, and the zealous co-operation of the body at large, the institution of these conversazioni may be made an important and not unprofitable feature in the sessional proceedings. The organisation of the arrangements, in which they trust they may be aided by an efficient committee, selected mainly from amongst the younger members of the Institute, will doubtless form one of the most interesting duties of the council during the ensuing session.

"The Architectural Exhibition and the Architectural Association have already taken possession of the galleries; and respectively inaugurated the event by very successful opening meetings.

"To the Architectural Exhibition Committee, its zealous Secretaries, and Treasurer, too much praise cannot be given for the spirited manner in which, in face of no ordinary difficulties, they originated the Architectural Union Company, which has carried to a most satisfactory conclusion the intention of providing in spacious, well lighted and well arranged galleries that amount of accommodation for the architectural world in London, which the Royal Academy denied within its walls; and afforded moreover constant means for the display of objects of utility as well as of artistic merit connected with building operations, never attempted before the establishment of the Architectural Exhibition.

"The council feel that they are expressing the feelings of the Institute, when they record their best wishes for the permanent success of the Architectural Union Company, which has united under one roof 'The Architectural Societies of London.'"

In addition to the subjects for papers and discussions brought before the ordinary general meetings, three of great interest have engaged the attention of meetings specially called to consider them. These are as follows, and it will be at once seen that their due investigation is of weighty importance as regards the prospective condition of the profession at large.

"The extension of the elective franchise as well to members of this Institute as to the members of other professions hitherto specially designated 'learned' (as proposed by Her Majesty's government), was considered an act of simple justice, which found expression in a petition agreed to unanimously at one of the meetings; which, having been duly authenticated by the corporate seal, was presented to the House of Commons by our Fellow, Mr. Tite, M.P. for Bath.

"The same unanimity prevailed respecting the necessity for supporting the prayer of a petition on the subject of artistic copyright, before a committee of the House of Lords about to consider the subject; and a committee of the Institute, consisting of Messrs. Donaldson, Godwin, Hayward, Kerr, Norton, and Papworth, has been named by the council (which had been duly empowered by the meeting), to press the purport of that petition before the Lords. Mr. Cockerell, Fellow, R.A., the council regret, is prevented by ill health from affording his valuable assistance as a member of the committee.

"A discussion in the House of Lords respecting the removal of the Royal Academy from Trafalgar-square, in order to devote the entire present building to the national collection, having called attention to the probable readjustment, if not of the constitution, at least of the working system, of the Royal Academy, a memorial to embody the views of the Institute on the subject was submitted to a special general meeting; and further considered at a second. At a third meeting a modified memorial to the council of the Royal Academy was agreed to in the following terms:—

"'The Institute of British Architects conceive it to be their duty at the present juncture, to offer their congratulations to the Royal Academy of Arts upon the probability of its speedily obtaining a site eligible for the erection of buildings more suitable for the requirements of the annual exhibition, library, art collections, schools, lectures, &c., than the premises it has hitherto occupied. By its steady maintenance of these and other educational institutions, it is undeniable that the Royal Academy has conferred inestimable benefits upon the fine arts of this country, and none can be more ready to subscribe to this fact than the Institute of British Architects. So highly indeed do they esteem the advantages which have been hitherto derived by the profession which they, to a certain extent, represent, that they cannot refrain from urging upon the Royal Academy in any re-adjustment of its present arrangements, the expediency, and indeed duty, of yet further extending and developing those advantages.

"'The Royal Institute of British Architects conceive it both more respectful to the Royal Academy, and less likely to prove prejudicial to its interests, to at once state openly their impression of the mode in which this can best be carried out, than it would be to remain silent, and yet not altogether satisfied with the prospect of the bare maintenance for the future of that which may have been sufficient in the past.

"'The following are the general arrangements which, if it were possible, the Royal Institute of British Architects would desire to see carried into effect by the Royal Academy:—

"'1st. A larger proportion of Architectural Royal Academicians and Associates to be appointed.

"'2nd. Powers of independent action to be given to the Architectural Members, upon matters connected with Architecture.

"'3rd. The provision of means of instruction in their art to be provided for Architectural Students, equivalent to those afforded by the Royal Academy to Students in any other branch of the Fine Arts.

"'4th. A more systematic scheme of general instruction in all branches of the Fine Arts to be brought into operation, and more efficient tests by examination, or otherwise, of knowledge and proficiency in practice.

"'The first point (the increase of architectural academicians and associates) the Royal Institute of British Architects conceive essentially due to the great extension which has of late years taken place in the study and practice of architecture, and its subservient arts of design in this country.

"'The second, independent action, is indispensable to prevent the architectural element being rendered powerless through its remaining on all occasions a small minority.

"'The third, architectural education, it is conceived, it would be incompatible with the comprehensive objects for which the Royal Academy was originally instituted, to refuse. And the fourth, a general elevation of academic art-teaching, is unquestionably demanded by the public for students in architecture, if not in all the other departments of the fine arts.

Digitized by Google

"'As considerable excitement is felt throughout the profession upon the subject of the present communication, it is proposed to give publicity both to it, and to whatever reply the Royal Academy may make to it.'

"The Institute must now await the result of this appeal to the good sense of the Royal Academy. The council must however express the sincere hope, that whatever course may be finally adopted by that body, it may be such as to confer material benefit on each and all of the equally important subdivisions of the fine arts.

"The council, in common it is believed with all well-wishers to the maintenance in an honourable position of the architectural profession, have felt and continue to feel profound anxiety with respect to the establishment of a more systematic course of education for the student in architecture than has hitherto prevailed. Looking naturally to the Royal Academy as the legitimate source of initiation, the council will seriously discuss and endeavour to originate some movement in this matter, in the event of the Royal Academy failing to provide a more active curriculum than it has hithertofore considered necessary. The subject is, however, obviously one of such extent and gravity, that any useful action can be only set on foot by the very hearty concurrence, not of the council or of the Institute alone, but of the whole body of architects practising in the United Kingdom."

Referring to the subject of architectural competitions, it is mentioned that the attention of the Council has been recently invited by Mr. Edward Barry to another phase which the matter is now occasionally assuming, viz., the practice of requiring competitors to undertake the task of deciding upon the designs submitted. The remarks of Mr. Barry were deemed by the council so pertinent, that they have felt that they could not do better than record them, as embodying a reasonable and logical statement of the case; being impressed with the necessity which exists that competitions (if competitions cannot be avoided) should be conducted in the best possible manner.

"In the absence of any expressed opinion on the part of the profession, it is not unlikely that this mode of determining competitions may become popular with those who conduct such matters, as at first sight it undoubtedly presents an impartial and captivating appearance. Isolated competitors can never hope to oppose with success regulations determined without their knowledge, nor can resistance be made effectually as each case arises. It is obvious that judgment of any kind which seeks to command respect, should proceed from a person or tribunal of *known* fitness for the task, and it may be doubted whether in a competition conducted anonymously, and in which the majority is likely to be composed of those who have their reputation to make, this essential condition can be adequately secured. Another point requiring much consideration is the difficulty of preventing collusion, fictitious voting, and other irregular acts, when strong personal feelings and private interests come into play, and when the corrective influence of public opinion can hardly be brought to bear. Instances may readily be imagined, when one competitor, who has sent in more than one design, may concentrate his several votes on one of the number; or when he might obtain votes from another competitor, who might feel his own chance hopeless, and who might be actuated by personal friendship or less creditable motives. There are besides many difficulties, such as the compulsory revelation of the names of the competitors who having been unsuccessful may not be desirous of publishing the fact, and also the equality of the authority of the votes, though the relative qualifications of the voters have not been in any way ascertained. This however is not the opportunity for entering at length upon the consideration of these difficulties, which may or may not be inherent to the nature of the case."

Besides these several topics, allusion is made to the "Nine hours movement" among the men employed in the various branches of trade connected with building; and also to the urgent call now existing for improving the main lines of intercourse through this rapidly-increasing metropolis. The attention of the legislature would seem to be now alive to the subject; and the system of railway communication is apparently on the eve of further development by the completion of the circuit round London, and by its continuation into the western centre at Charing Cross.

The retirement of Mr. Digby Wyatt from the office of joint Honorary Secretary is announced;—that gentleman having accepted the duty three years ago on the understanding that he should be at liberty to relinquish it at the expiration of a twelvemonth. His connection however with the new position of the Institute induced him to continue his services till the present time, when he has the satisfaction of seeing future arrangements so far complete as to leave comparatively little on that score to be accomplished by his successor, Mr. T. Hayter Lewis.

The Council also notify with sentiments of deep regret that their late Honorary Secretary for Foreign Correspondence, Mr. T. L. Donaldson, who had long held that position with much efficiency, has communicated his wish to be released from office, a notification which they have had, of course, "to accept and deplore."

"For twenty years that office has been held by Mr. Donaldson with honour to himself and benefit to the profession both at home and abroad, and for several years previously to his acceptance of that office the even more onerous duties of joint honorary secretary had been no less sedulously and creditably performed by the same gentleman. No resolution, however powerfully it may be worded, can be adequate to convey a just impression of the council's estimation of such services given for so long a period—so freely, zealously, and with an enlightened jealousy for the conservation at all times and under all circumstances of the best interests of the art and its professors. They desire, nevertheless, to place upon their minutes this inadequate record of the feelings of gratitude which they will ever entertain towards Mr. Donaldson for his untiring labours to uphold this Institution, and all that is most worthy of admiration in the cultivation and practice of the fine arts."

At the request of the Council, Mr. F. C. Penrose has allowed himself to be put in nomination as Mr. Donaldson's successor. The list of office-bearers for the new session includes the names of Earl de Grey as President; Messrs. Ashton, R. C. Hussey, and Godwin as Vice-Presidents, and C. C. Nelson and T. H. Lewis as Honorary Secretaries.

THE JEWS' NEW HOSPITAL, MILE END.

In the early part of this year designs were advertised for, with offers of premiums to the three which should be ultimately most approved, with a view to the erection of a new hospital for this institution. The instructions laid down were very clear and explicit, and the names of the intended adjudicators, Messrs. D. Mocatta and M. Digby Wyatt, were also published. The competition drawings were lately sent in, and the adjudication being made, they have been on view to the public during the week just closed, at Sussex Hall, Leadenhall-street, in compliance with a suggestion made in the judges' report, to which we shall again refer.

There were thirty-three designs forwarded in answer to the advertisements, and the report expresses, in more laudatory terms than perhaps we should have been disposed to do, an opinion as to the "high average of excellence" that presented itself. The style which seems most in favour among their authors appears to be the Italian, more or less freely used; some few are decidedly Gothic, introducing foreign elements, and two or three may be described as Romanesque, for want of a better term. The three premiums have been, oddly enough, distributed among these three classes; the first (of £100) to Messrs. Tillott and Chamberlain; the second (of £50) to Mr. C. H. Cooke; and the third (of £30) to Mr. J. P. Jones, their respective mottoes being "Experientia," "Faith," and "Alpha." In arriving at the decision, which appears to have been done with great impartiality, the judges explain the course they followed, viz., by making their examination individually at first, and then comparing notes, reducing the number for a final consideration to eight, which they considered "apparently eligible for reward." There were however found drawbacks in some of these which led to their being set aside, such as extravagance, want of supervision, inconvenient arrangement, or defective construction or design. Ultimately the number was brought down to *six*, which were submitted to the surveyor to the charity, Mr. S. B. Wilson, for the purpose of ascertaining, by means of "quantities," the probable comparative cost which each of these would involve if carried out. The completeness of the drawings and specification furnished by "Experientia" enabled him as regards that design to do this with tolerable certainty, and furnished data for the estimation of the others, and Mr. Wilson gave in his figures to the referees, who requested him to re-investigate the matter, subject to certain modifications which would place the authors of the designs on a more equal footing. The result, as shown in Mr. Wilson's second report, dated June 7th, exhibits the relative cost of the three designs which seemed most deserving as—

"Experientia"	£10,813
"Faith"	11,124
"Alpha"	11,478

Taking into account the average variation of amounts of tenders in competition for similar buildings, the adjudicators "see no reason to positively reject any of the designs on the score of excessive expense, as we believe that, according to either of these

Digitized by Google

designs, a building might be executed which should fulfil all the conditions we had made imperative upon the competitors."

With respect to the special merits of these three designs, and of the remaining three of the six eligible sets to which they reduced the entire collection, they remark:—

"That the design 'Experientia' will be found to afford the whole of the prescribed accomodation in a remarkably compact, and consequently economical form; the arrangement for air, light, subdivision, freedom of communication, and convenience of economical household service, leave nothing to be desired; while in the important point of so limiting the frontage as to admit a perfect circulation of air around the whole building it stands alone. The external appearance of this building, should it be carried into execution, will prove satisfactory, avoiding alike any very marked assumption of peculiar style and any extravagance of effect. It would be handsome and appropriate, and would be rather improved than injured by the proposed diminution in height. The proportions of the first-floor windows and the roofs over the angle pavilions might be improved by judicious study and retrenchment.

"The design marked 'Faith' is the work of a good practical architect, being both well planned and gracefully designed. It wants, however, the compactness of 'Experientia's' arrangement, and could not be so conveniently or economically administered. The boys' school-room and the large dormitories would be scarcely lofty enough for their area on plan. It is however, upon the whole, a highly meritorious design.

"The design marked 'Alpha' is not quite equal to the last named, being defective in some of its lavatory arrangements and servants' bed-rooms. In picturseque grouping of the various buildings, as seen from the grounds of the establishment, it is superior to any other design of the whole series. The front is also well drawn, but is not quite consistently carried out in its leading features. With regard to the remaining three designs which deserve commendation, although not among the premiated, we desire to record, in the first place, our admiration of the picturesque arrangement adopted by the author of the design marked 'Celsus,' and of the merit of his plan, with one feature of which —the bringing forward to the front in detached buildings of the aged persons' house and infirmary—we were much pleased. We could not, however, bring ourselves to believe that this picturesque grouping and effect could be attained for the amount to which your contemplated outlay has been limited.

"With respect to the designs marked 'Veritas, No. 2,' and 'Economy,' we would remark that in both a compact and utilitarian distribution on plan is combined with sedulous endeavour to restrain expenditure within prudent limits."

The author of the design marked "Celsus" proves to be Mr. G. Morgan, of Danes'-inn; and of that marked "Veritas," Mr. H. H. Collins, of Torrington-square. There does not appear any name answering to that entitled "Economy."

It may be added that the building is for the reception of 100 boys and 40 girls, and is to include, with dormitories and school rooms, a dining-room for 150 persons, a synagogue 37 by 24 feet, and a detached building for six aged males and six aged females.

WATERGLASS, AND ITS PROPERTIES.

We took occasion in a previous number of our Journal (Sept. 1858) to describe at some length the properties of the chemical application for preserving materials known as "Waterglass;" we are now enabled to supply some additional facts, contributed by one of the earliest experimentalists on the subject, Dr. Johann Nep. Fuchs, in a paper which has been translated by desire of, and communicated to the Society of Arts by H.R.H. the Prince Consort, its president. The document touches upon a vaoiety of themes which, as they do not bear upon questions which it is not our province to lay before our readers, we need not further allude to, while their omission will greatly curtail the use that might be made of a really valuable contribution to science. (The whole will be found printed at length in a recent number of the Society's Journal.)

So far back as the year 1825 the learned author published a paper on "Waterglass," which at that time, however, did not meet with the attention which the subject well deserved. This was partly attributable to the non-success of certain experiments which were undertaken without the necessary previous acquaintance with the subject. Great were the expectations raised by the discovery. Failures, owing perhaps to faulty manipulation, frequently caused it to be abandoned before it had been put to a fair test.

The manufacture and the properties of the waterglass have been fully described in Kastner's Archiv., but Dr. Fuchs has thought it desirable to reproduce the more essential parts of that paper, since he is able to introduce many improvements, and to treat more amply of things which at that time were but cursorily indicated.

Various kinds of Waterglass, and their Manufacture.

"We have to distinguish four kinds of waterglass:—*a*. Potash waterglass. *b*. Soda waterglass. *c*. Double waterglass. *d*. Fixing waterglass.

"The name 'waterglass' is, in fact, a generic name employed when speaking of the above four varieties. I do not know whether a lithia waterglass might be obtained. Perhaps a good double waterglass of potash and lithia might be produced by replacing a part of the potash by lithia, for which purpose lepidolite could be conveniently employed. This double waterglass would no doubt be rather expensive; cases might, however, occur where expense would be a matter of secondary importance.

"I was for a long time of opinion that the ordinary waterglass, after being completely saturated with silica, forms the best and the most suitable for all purposes."

"(Freshly precipitated or gelatinous silica offers the best and most convenient means of ascertaining whether a sample of waterglass is completely saturated with silica, by introducing it in small portions into the boiling liquid, when a saturated solution will dissolve no more, whilst an incompletely saturated solution takes up more or less.)

"A serious inconvenience, however, showed itself in its application to stereochromy; in the last operation, that of fixing the colours, the pictures assumed a cloudy and dirty appearance in consequence of the rapid partial decomposition of the waterglass. This drawback caused much anxiety, and suggested the idea that in this case the waterglass ought not to be completely saturated with silica. A few experiments proved this opinion to be correct; and by adding a portion of soda liquor silicum, or soluble silicate of soda, to the ordinary waterglass completely saturated with silica, I obtained a waterglass which perfectly answered the purpose. I call this mixture *fixing waterglass*.

Properties of Waterglass, and its deportment with other Bodies.

"It is important to study thoroughly its action upon other bodies in order to prevent errors, or drawing erroneous conclusions from certain changes or phenomena.

"Solid or fused waterglass, if pure, has the appearance of ordinary glass, and dissolves gradually but completely in boiling water; in the cold, however, the solution proceeds so slowly, that one feels inclined to believe that it is entirely insoluble in cold water. It becomes entirely insoluble only when a much larger quantity of silica has been added and made to combine with it, or when a portion of potash has been withdrawn; frequently, also, when other bodies, viz., earths or oxides of the metals, &c., have been mixed with it, which form double or triple silicates, such as many mineral compounds and common glass itself is composed of; for I have always noticed that silicate combines more readily with two bases than with one.

"Acids—carbonic acid not even excepted—decompose the solution and separate silica in a gelatinous form. Solid waterglass is readily acted upon by dilute acids, and silica is separated in the form of a powder.

"Salts of the alkalies, especially the alkaline carbonates or chlorides, cause viscous precipitates from a concentrated solution, and the whole solution seems to coagulate. In dilute solutions, a precipitate appears only after some time. Sal-ammoniac acts most powerfully by producing, even in a very dilute solution of the waterglass, a flaky precipitate, ammonia being simultaneously evolved. On washing this precipitate with water acidulated with nitric acid, pure silica is left on the filter.

"The alkaline earths set free more or less potash on being brought into contact with a solution of waterglass, and combine with the rest of the potash to form double salts which are quite insoluble in water.

"Alumina combines likewise with it, and forms a product insoluble in water; it is therefore necessary that the quartz which is used in the manufacture of waterglass should not contain any alumina. The insoluble residue which is left behind when the fused mass is dissolved in water, is probably owing to the alumina which the glass has taken up from the glass-pot.

"If the waterglass is dissolved and exposed to the air in open vessels, it attracts carbonic acid and suffers decomposition, which causes it to coagulate sooner or later, and produces gradually a slimy deposit, which was found by Professor Buckner to contain potash.

"Heat accelerates this decomposition. If the liquid is evaporated and the dry mass made anhydrous by further heating, it swells considerably, and will then be almost entirely decomposed. Water no longer dissolves it, and acids produce strong effervescence. By calcination it is

Digitized by Google

brought back to its original state, and becomes again completely soluble in water.

"It is evident that constant boiling is required to obtain the soluble waterglass in a solid state by means of evaporation, in order to prevent the carbonic acid from penetrating the mass. The same precaution must be observed when fused waterglass has to be dissolved, and care must be taken always to add boiling water in order not to interrupt the ebullition, and thus to allow the access of carbonic acid.

"When solid or pulverised waterglass is exposed for some time to the action of the atmosphere, it undergoes the same change as during the evaporation. It effervesces strongly on addition of acids, and is only partly soluble in water, leaving a heavy desposit. On being strongly ignited, this residue becomes again soluble. If a drop is allowed to fall on the table or on the floor, it soon loses its transparency and becomes opaque, owing to a partial decomposition. The same takes place when it is poured from a bottle and a drop runs down outside the vessel; white streaks, which are difficult to efface, make their appearance. If the liquid glass is kept in a bottle which is only half-full and badly stoppered, a white deposit or ring is formed after a short time, which adheres so firmly that it cannot be removed entirely even by acids, and a more or less heavy deposit is found on the bottom of the vessel, owing to a partial decomposition of the waterglass—a fact which I did not become aware of for some time, on account of insufficient experiments and observations.

"When concentrated waterglass is brushed upon a solid substance, such as glass, marble, or thick paper, it soon dries up and forms a shining transparent coating, which, however, does not keep long, but becomes gradually dull, opaque, and sometimes fissile and cracked, and of a somewhat pulverulent appearance. This gradual change is caused by water, which the air-dried waterglass retains in rather considerable quantity (about 12 per cent.), and which it loses but slowly, whilst it contracts more and more and acquires considerable hardness.

"One of the most important properties of the waterglass, and one which renders it most suitable for practical purposes, is its binding and cementing power; it may be employed for imparting solidity and greater cohesion to loose masses, for joining separate parts of bodies or small particles to form a large whole, for filling up cracks or fissures, &c., and many more applications. Its action resembles that of glue; and it might, in fact, be called a mineral glue.

"Its effects are most apparent when it is applied upon solid porous bodies which absorb it, and when it is brought together with pulverulent dust or sand-like bodies, or with substances which can be crumpled up between the fingers, but which are converted into a stone-like mass, from which the waterglass can no longer be dissolved.

"The intensity of the effect produced depends upon the nature of the substances with which the waterglass is brought into contact; some possess a stronger affinity than others, and consequently are more powerfully cemented than others. There is, however, this essential difference, that a few, such as magnesia and oxide of zinc form with the waterglass a chemical compound, whilst others are only mechanically combined, owing to mere adhesive action. The former action, by which bodies are rendered hard and insoluble, will be readily understood, because an insoluble double silicate is formed by the combination with a second base. The latter is more difficult to explain, especially since the waterglass shows a slightly different deportment with different bodies, and it is therefore not at all immaterial which body is chosen in order to obtain an intimate solid mass which resists the action of the water. Thus, for instance, waterglass exhibits a much greater power of adhesion for powdered marble than for powdered quartz. It has been shown, moreover, that the carbonic acid of the air promotes the consolidation of the waterglass, because it is partially decomposed when exposed to the air; however, this is not sufficient to explain the striking change which frequently becomes perceptible after the lapse of a few days. Carbonic acid, no doubt, loosens the slight tie which exists between silica and the alkali; but then the former does not remain passive, passing, according to its peculiar nature, through various states of cohesion, becoming itself active, retiring, so to speak, entirely upon itself, and cohering so intimately with the particles of the body with which it is brought into contact, and for which it possesses a strong adhesion, that the whole mass becomes petrified. If, therefore, a body does not readily cement with waterglass, it will only be necessary to add a material which combines chemically with the latter, when the desired end is sure to be obtained.

"I call a mixture of pulverulent or sand-like bodies with waterglass which cements well, *waterglass cement*. It may be advantageously employed in various cases instead of the common chalk-cement, as will be shown hereafter.

"Waterglass imparts considerable hardness to porous bodies which absorb it, such as vessels of baked clay, plates, bricks, tiles, pottery-ware, &c.; as also to porous limestones, sandstones, and to timber.

"It has been stated that waterglass does not cement all solid bodies equally well, and it will be interesting to know which bodies are more or less inclined to combine with it. I will mention only those which are available for practical purposes, and state the experiments which were made to ascertain their deportment.

A.—Carbonate of Lime.—(Chalk, Calcareous Sand, Powdered Marble.)

"When chalk-powder is made into a paste with water and then well dried and saturated with waterglass, it forms a compact mass. According to Buchner, if a piece of chalk is plunged into a moderately concentrated solution of waterglass, and left for about two days in the solution, then taken out, dried, and again put into a somewhat more dilute solution, it is found to be entirely soaked with it, and acquires on drying such an even hardness that it is very little inferior to marble, and capable of a good polish. Water does not soften it, though it assumes a slight alkaline reaction; the chalk is also increased considerably in density. Baron Liebig and Professor Buchner have confirmed this remarkable deportment of waterglass by their own experiments. Chalk therefore forms an excellent ingredient in order to render waterglass cohesive and insoluble in water.

"Powdered marble exerts the same action upon waterglass as chalk, and forms a very compact mass with it, especially a very good cement. This cement, which may be prepared of more or less coarsely-powdered marble, may find useful application for many practical purposes, as well as the analogous mass of chalk and waterglass, since it adheres to wood as well as stone.

B.—Dolomite,

"A mineral consisting of carbonate of lime and carbonate of magnesia, which, according to experiments lately made, appears to surpass even limestone in its cementing power; and as it is considerably harder than limestone, a mixture of its powder with waterglass imparts a strong resisting power against external mechanical as well as chemical action. It may be classed with the best means of cementing the waterglass and to render it insoluble in water; and since it occurs frequently in nature, it may be obtained without incurring any great expense.

C.—Phosphate of Lime.—(Bone-ash.)

"Phosphate of lime also gives a very compact mass with waterglass, scarcely differing in consistency from that with carbonate of lime, and, as far as has been ascertained, without undergoing any chemical action or change of its constituents. Although it is not likely that phosphate of lime will be much employed, it is interesting to know its deportment with waterglass, because it is sometimes formed by the combination of phosphoric acid and lime and brought into contact with waterglass, as will be further illustrated hereafter.

D. Caustic Lime.—(Slaked Lime.)

"Waterglass sets rapidly when caustic lime is mixed with it, and dries slowly to a rather hard mass. A chemical combination takes place between the lime and waterglass, and potash is liberated, if a sufficient quantity of waterglass be present. It is evident that water has no action upon this product. It may serve advantageously as an admixture to other masses which do not cement so well; only little can be added, however, lest the solution sets and prevents the waterglass from penetrating.

E.—Lime acted upon by the Atmosphere—(Basic Carbonate of Lime)

"May conveniently be added to waterglass by rubbing the two substances together; it does not set rapidly, but dries up gradually to a solid mass, which is a chemical product consisting of silicate of potash and lime. Slaked lime forms a useful addition to other masses, since it will soon be converted into carbonate of lime by the action of the carbonic acid of the air; and walls coated with mortar may, after a short time, be impregnated with waterglass in order to cement them better.

F.—Pulverulent Quartz.

"Quartz may be powdered as finely as possible without exhibiting any strong adhesive power or inclination to form a cement with the waterglass. If it be made into a kind of cement, and placed upon a tile moistened with waterglass, it dries up to a solid mass after a few days, and resists rain, and becomes as hard as a stone on the surface. But if that surface is pierced and the inner part examined, it is found quite disintegrated and void of waterglass, the whole of which has been drawn to the surface. Repeated soaking in waterglass is necessary to render the mass homogeneous. A compact mass which leaves scarcely anything to wish for, is however obtained when a little dry-slaked lime is mixed with the powdered quartz, and then the mixture treated with waterglass.

"The same takes place when waterglass is added to mortar made with quartz-sand and slaked lime, after the mass has been well dried.

G.—Burned Clay, and Burned Porcelain Clay.

"These two bodies do not belong to those which bind well with waterglass. We observe the same action as with powdered quartz. The waterglass only combines superficially with them, and leaves underneath a porous powder, which will only bind if repeatedly moistened with waterglass.

"There exists a remarkable difference between vessels made of different kinds of clay, which become, as is usual, porous by burning, so that they absorb the waterglass readily. If, for instance, a burned plate of potter's clay which possesses no particular hardness, and can easily be broken to pieces, is saturated with moderately concentrated waterglass, and if the soaking is repeated after it has become dry, it is rendered so hard that it resists both chemical and mechanical action which is made to bear upon it.

H.—Zinc White (Oxide of Zinc) and Magnesia.

"These two bodies combine most energetically with the waterglass, and

Digitized by Google

hereby show the same close analogy which we notice in several others of their natural as well as artificial chemical compounds.

"If the mixture of oxide of zinc and the waterglass is brushed in a thin layer upon objects, it adheres firmly to them and gives a good coating, to which a colour may be added, if desired.

"This powerful action of the oxide of zinc makes it a very useful article to add to those substances which, by themselves, do not bind readily with waterglass. Even to those that do, a small admixture of the salt can be advantageous, and tends to increase the solidity, or, at all events, prevents the waterglass from making its way to the surface.

"*Gypsum.*—Hydrated Sulphate of Lime (CaO, SO^3+2HO).—When gypsum is ground together with waterglass it solidifies immediately, and on drying much sulphate of potash or sulphate of soda separates, according as potash waterglass or soda waterglass has been employed in the experiment. The mass is however scarcely more solid than the ordinary gypsum. No doubt a chemical action has taken place. It follows that objects made of gypsum cannot be impregnated with waterglass in order to render them more solid and capable of resisting the action of the atmosphere, because it does not penetrate into the pores. Gypsum must therefore be avoided in selecting admixtures for the waterglass; moreover, care must be taken to avoid such bodies as might form gypsum in the operation, or as might already contain gypsum.

"*Anhydrite*, or anhydrous sulphate of lime, and I think strongly ignited gypsum, promise a better result; but I am unable to speak definitively on this point, as the experiments have not yet been brought to a conclusion.

"The late sculptor Professor Maier told me, that he was enabled to employ a faulty stone in a few days as if it had contained no fissure, by dropping a few drops of soda waterglass into the crevices. He could not employ potash waterglass equally well, since it was not so liquid, and did not penetrate into the fissures.

"The question will be asked, which of the several kinds of waterglass answers best, and is the most suitable for practical purposes. Nothing definite can be stated as yet. It is possible that the potash waterglass, which sets more rapidly than soda waterglass with powdered substances with which it is mixed, may impart greater solidity to them than soda waterglass; the difference however cannot be considerable. On the other hand, the soda waterglass has the advantage of being more liquid, and penetrating more readily into the smallest spaces, pores and fissures, than the slightly gelatinous and difficultly soluble potash waterglass, a property which is of some importance to the sculptor and mason. Soda does not combine so strongly with silica as potash, and has a strong inclination to efflorescence when combined with the carbonic acid of the air; and one of the advantages of soda waterglass might be due, therefore, to its parting readily with the silica, and thus accelerating the silicatisation of the mass. Further experiments, however, are required to prove its superiority.

"The double waterglass seems to unite the properties of the other two, and merits preference, for the very reason that it contains two bases (potash and soda) with which silica (which prefers to form double compounds) combines more powerfully.

"The fixing waterglass is used for the particular purpose already stated, but it can also be employed in many other cases, especially in painting.

"The first three kinds of waterglass, when completely saturated with silica, are always more or less cloudy or opaque, owing to undissolved and very finely divided silica.

"In order to deprive them of this opacity, it is sufficient to add a little liquor silicum, and to allow them to stand for about a day, stirring them occasionally. The opacity disappears completely, and the liquid becomes perfectly clear, provided it be not accidentally coloured by some other (organic) substance."

We purpose recurring to this important question on some future opportunity.

ST. JOHN'S CHURCH, HIGHBRIDGE, SOMERSETSHIRE.

This church, which is prettily situated in the parish of Burnham, on the coast of the Bristol channel, was consecrated on the 20th of last month. It has been erected solely at the expense of Mrs. H. Luttrell, of Badgworth Court, to meet the requirements of a rapidly increasing population at the newly-opened inland communication: a regular steam service now established with South Wales having caused Highbridge to become an important port.

The plan of the church consists of a nave of five arches in length well proportioned,—and chancel, the former having also an aisle, and the latter a chapel attached. The tower is placed at the north-west angle of the church, and contains four bells, by Warner, of London; its lower stage serves as a principal entrance to the church. Provision is made for the erection at some future time of a south aisle, to correspond with that of the north. The peculiar feature of the interior is the treatment of the nave arcade, the arches of which have a square soffit enriched with running ornament; this soffit is of the whole thickness of the wall, except that a small roll moulding takes off the squareness of the angles. These arches spring, not as usual from simple pillars, but from too small coupled columns placed transversely to the direction of the wall above. The small size of these columns (only 7 inches diameter) and the beauty of the material, which is polished Babicombe marble, impart a rich and elegant effect, as excellent as it is novel; while it has the further advantage of intercepting the view far less than by the ordinary arrangement.

Externally the walling of the church is constructed of blue limestone, procured from quarries at Weston; the relieving arches and banding are of red sandstone from Mount Radford, near Bridgewater. Combe Down stone is used for the dressings, and the roofs are covered with blue and red tiles laid in alternate colours. The pulpit is of stone, and has its upper part enriched with encaustic tiles, while emblems and monograms, inlaid, adorn the several faces.

The font is handsome, and supported on four marble columns. Portions of the woodwork, such as the seating, doors, and screens, have been executed in chesnut, oak being used in the chancel stalls.

The works have been ably carried out from the designs of the architect, Mr. Norton, by Mr. Palmer, of Weston-super-Mare, who has also built, under the same direction, the adjoining parsonage-house. The church accommodates at present 360 persons, and has cost about £2500; the erection of the house cost only £900.

NOTES ON STATICS.

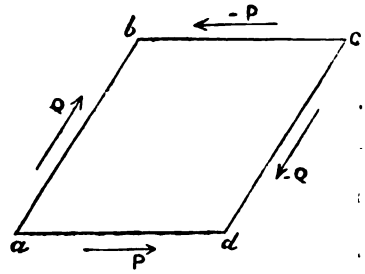
After having proved the theorem of the Parallelogram of Forces, and a few propositions that immediately flow from that theorem, it is usual to demonstrate the principle of the lever, and to deduce from the latter principle the properties of couples. This method however involves, so to speak, a great waste of demonstration, and the following sketch seems to us to indicate a mode of proceeding both more simple and more philosophical.

After having proved *the Parallelogram of Forces*, we proceed to define a couple to be a system of two equal parallel and opposite forces acting respectively at two points rigidly connected, the arm of the couple to be the distance between the two forces, and the moment of the couple to be the product of the arm and the force. We assume that a force acting on a rigid body may, without altering its effect, be transferred to any point of its line of action.

A couple may be denoted by (P, *a b*, —P) or by (P, *a b*) where P and —P are the two forces, and *a* and *b* are any two points of their respective lines of action.

If then on turning from the direction of *a b* round to that of —P, or from the direction of *b a* round to that of P, we are proceeding in the positive direction of revolution, the couple and its moment are called positive, and in the opposite case negative. Couples which are both positive or both negative, (if both in the same plane), may be called similar couples; and couples in the same plane of which one is positive and the other negative may be called opposite couples.

Let *a b c d* be a parallelogram; let *a d*, *a b* represent respectively two forces P and Q, and *c b*, *c d* two equal parallel and opposite forces —P, —Q; then those four forces are in equilibrium; since the resultant of P and Q is represented by *a c*, and that of —P and —Q by *c a*.



But the four forces constitute two couples (P, *a b*, —P) and (Q, *b a*, —Q); the moment of each couple is evidently measured by the area of the parallelogram, and therefore the couples are equimomental, and they are also opposite to one another.

The converse of the above may be easily shown.

Let (P and —P), (Q and —Q) be two equimomental opposite couples in the same plane; then if the forces of the one couple be

Digitized by Google

not parallel to those of the other, their lines of action if produced will meet and form a parallelogram $a\ b\ c\ d$. Let the arm of the couple (P and $-$P) be p, and the arm of the other couple be q; then since the two couples are equimomental we have

$$Pp = Qq.$$

But, $$ab \,.\, q = \text{area of } a\ b\ c\ d = ad \,.\, p$$

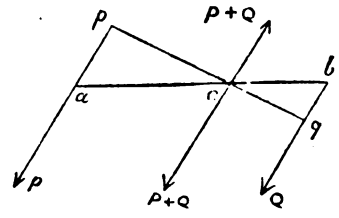
$$\therefore P : Q :: ad : ab;$$

and therefore by the former proposition the two couples balance one another.

Whence it follows that a couple is equivalent to any other equimomental and similar couple in the same plane, provided the forces of the one couple meet those of the other; and if the forces of the two couples are parallel to one another, then by comparing each with an equimomental couple, the forces of which meet those of the other couples, we see that also such two couples are equivalent to one another. We have thus proved the proposition, that a couple is equivalent to any other equimomental or similar couple in the same plane.

From the above follows at once the principle of the lever.

Let P and Q be two parallel forces acting at a and b respectively; draw ab, and on it take c, such that $P \,.\, ca = Q \,.\, cb$. Draw pcq perpendicular on the direction of P and Q. At c apply forces P+Q and $-$(P+Q) parallel to P and Q. Then P at a and Q at b are equivalent to P+Q at c, and two couples namely (P, ac, $-$P) and (Q, bc, $-$Q); and since $cp : cq :: ca : bc$



$\therefore P \,.\, cp = Q \,.\, cq$; therefore the two couples are equimomental, and being opposite couples and in the same plane balance one another. Therefore P at a and Q at b are equivalent to P+Q at c; which is the principle of the lever.

We may show at once in the usual way that as two similar equimomental couples in the same plane balance one another, therefore the resultant of any number of couples in the same plane is a couple having for its moment the sum of the moments of the given couples, the moments being affected with their proper signs; this namely becomes evident by substituting for the given couples respectively equimomental couples having all one and the same arm equal to unity.

Since a force P at a is equivalent to P at a, and $+$P and $-$P at any other point O, it follows that P at a is equivalent to P at O, and a couple (P, aO, $-$P), or a couple whose moment is Pp, p being the perpendicular from O on P at a. If therefore any number of forces PP'...in one plane act on a body, and O being a point in that plane, pp'... are the perpendiculars respectively from O in the direction of the forces, it is easy to see that the given system of forces is equivalent to the resultant of PP'... transported without altering their directions to O, and to a couple whose moment equals $\Sigma(Pp) = G$ say.

If $\Sigma(Pp) = G$ does not equal zero, then the couple may be transferred to O, the point where R the resultant of PP'... acts. Now for this couple we may substitute another one having at O a force $-$R; then the other force of the couple will be R acting at A,

A being such that Oa is perpendicular on R and is equal to $\frac{G}{R}$

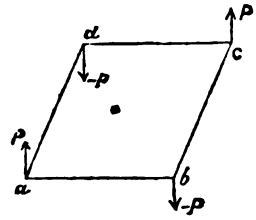
To this force R, then, the system is reduced. Let now Pp be called the moment of the force P with respect to O, then the resultant of a system of forces in one plane is either a couple whose moment equals the sum of the moments of the forces, or a force R having for its moment the sum of the moments of the forces; or finally the system is in equilibrium.

If P, P_1, P_2...be parallel forces acting at points a, a_1, a_2,...respectively of a straight line O, a, a_1..., and if the resultant ΣP of the system passes through h a point on that straight line, and is at a distance r from O, we must have $Rr = \Sigma Pp$, or as $r\ p$, p_1 &c. are clearly proportional to Oh, Oa, Oa_1..., respectively we have.

$$R \,.\, oh = \Sigma P \,.\, (Oa) \qquad \text{.....(A)}$$

$\therefore$ Oh is independent of the direction of P.

Now let $abcd$ be a parallelogram. Let P, P be equal parallel forces acting at a and c respectively, but not necessarily in the plane of the parallelogram. Let $-$P, $-$P be equal and parallel forces opposite to the former and acting at d and b respectively; then since P at a and P at c have for their resultant 2P at the centre of the parallelogram, and $-$P at d and $-$P at b have for their resultant $-$2P also at the centre, it follows that the four forces are in equilibrium, and adding to that

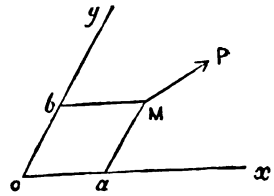


system a force P at b, we see that P at b is equivalent to $-$P at d, and P at a, and P at c. So that we have the following proposition, which will prove to be a very useful one:

A force P *at a point* b, *is equivalent to the force* P *transferred to any two points* a *and* c, *and a force* $-$P *at the other extremity of the diagonal of the parallelogram constructed on* ba, *and* bc. (B)

From the above we may at once deduce the property of the centre of parallel forces in one plane.

Let P be a force at M. Let Ox, Oy be co-ordinate axes, O$a = x$, O$b = y$; P at M is equivalent to P at a, P at b, $-$P at O; and proceeding in the same way with any number of parallel forces, we find according to proposition (A) the system to be equivalent to $-\Sigma$P at O, Σ(P) at h on Ox where $Oh = \frac{\Sigma Px}{\Sigma P}$, and to ΣP at k on Oy where $Ok = \frac{\Sigma(Py)}{\Sigma(P)}$; and these three forces



are by the preceding proposition equivalent to ΣP at the point whose co-ordinates are h and k, a point therefore independent of the direction of the parallel forces.

We proceed now to a system of forces not in the same plane.

Let us first explain a notation which it will be sometimes found convenient to use.

(P) + (Q) denotes the resultant of forces P and Q.

(−Q) denotes a force equal and opposite to Q, in fact a force balancing Q.

(P) − (Q) denotes the same as (P) + (−Q).

(P) + (Q)=(R) means that R is the resultant of P and Q.

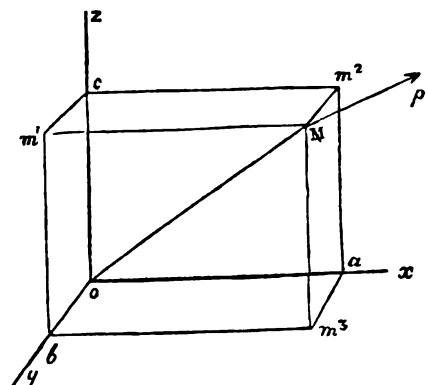
Then it is easy to show that if

$$(P) + (Q) = (R)$$
$$(P) - (R) = (Q)$$
$$(P) + (Q) - (R) = 0;$$

in short, that the ordinary rules for transferring quantities from one side of an equation to another hold good.

We shall therefore call (P) + (Q) *the complete sum* of the forces P and Q, and (P) − (Q) *the complete difference* between P and Q; and shall apply the same terms and definitions to P and Q when they represent straight lines, and certain other magnitudes capable of being represented by straight lines.

Let Ox, Oy, Oz be co-ordinate axes rectangular or oblique, P a



force acting at M, whose co-ordinates are O$a = x$, O$b = y$, O$c = z$ Draw Mm_1, Mm_2, Mm_3 parallel respectively to Ox, Oy, Oz to meet the co-ordinate planes at m_1, m_2, m_3, respectively. Let us

Digitized by Google

construct the parallelopiped formed by joining these points. Since $cMOm_3$ is a parallelogram we have from proposition (B) that

$$(P \text{ at } M) = (P \text{ at } c) + (P \text{ at } m_3) - (P \text{ at } O).$$

For a similar reason

$$(P \text{ at } m_3) = (P \text{ at } a) + (P \text{ at } b) - (P \text{ at } O)$$

$$\therefore (P \text{ at } M) = (P \text{ at } a) + (P \text{ at } b) + (P \text{ at } c) - (2P \text{ at } O)$$

Thus we have the following generalization of proposition (B):

P *at* M=P *transported to any three points a, b, c, together with* −2P *at the corner opposite to* M *of the parallelopiped constructed through* M, *c, a and b.*

From this proposition we might deduce the properties and co-ordinates of the centre of parallel forces in space exactly as has been done before for parallel forces in one plane.

Let XYZ be the respective components of P parallel to Ox, Oy, Oz. Let P_z be the projection of P on the plane of yx by lines parallel to Ox, and let P_y, P_x denote similarly the two projections in the other co-ordinate planes. Then P_z is the resultant of Y and Z. Or,

$$P_z = (Y) + (Z)$$
$$P_y = (Z) + (X)$$
$$P_x = (X) + (Y)$$
$$\therefore (P_z) + (P_y) + (P_x) = (2X) + (2Y) + (2Z) = 2P$$

$$\text{Now } X \text{ at } M = X \text{ at } M_1 = X \text{ at } c + X \text{ at } b - X \text{ at } O$$
$$Y \text{ at } M = Y \text{ at } a + Y \text{ at } c - Y \text{ at } O$$
$$Z \text{ at } M = Z \text{ at } b + Z \text{ at } a - Z \text{ at } O$$

$$\therefore P \text{ at } M = X \text{ at } c + Z \text{ at } a + Y \text{ at } a + X \text{ at } b + Z \text{ at } b + Y \text{ at } c - P \text{ at } O$$
$$= P_y \text{ at } m_2 + P_x \text{ at } M_3 + P_z \text{ at } m_1 - P \text{ at } O$$

That is to say, a force P *is equivalent to the force projected on any three planes together with* −P *at the point of intersection of the three planes.*

And from the above follows at once that a couple (P, MO, −P) is equivalent to three couples (P_y, m_2 O), (P_x, m_3 O), (P_z, m_1 O).

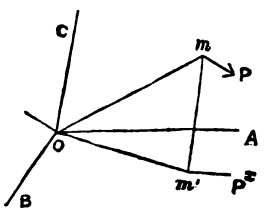
Moreover since P at M = P at O and a couple (P, MO, −P), we can easily see that a system of forces PP_1P_2, &c., is equivalent to the forces transferred to O, and to three couples in the co-ordinate planes, which couples may be respectively denoted by

$$L = \Sigma(P_x, m_1 O) \text{ in the plane of } yz$$
$$M = \Sigma(P_y, m_2 O) \quad ,, \quad zx$$
$$N = \Sigma(P_z, m_3 O) \quad ,, \quad xy$$

Whence follow the ordinary analytical formulæ.

By means of the above we may also solve the following problem:—

It is required to decompose a couple (P, MO, − P) into three couples in three given planes, BOA, BOC, COA.



The couple in the plane BOA is found by projecting the force at M on the plane BOA by lines parallel to CO. Let such projection be P_z at m_1, then the required couple in the plane BOA is (P_z, m_1 O, $-P_z$); and similarly for the other planes.

ON A NEW FORM OF TELEGRAPH CABLE INTENDED TO REDUCE THE EFFECTS OF INDUCTIVE ACTION.*

By J. N. Hearder, Electrician, Plymouth.

In relation to the existing Atlantic cable, the only assistance which it could possibly afford, would be in very slightly improving the character of the earth discharge. I here avoid the term earth-circuit, because I do not believe that, except under very peculiar circumstances and within very limited bounds, any appreciable return current takes place through the earth. We must indeed look upon the earth as a great reservoir, capable with proper arrangements of affording any supply, or of disposing of any discharge. If the Atlantic cable were a tube carrying water instead of electricity, receiving it at one end and discharging it at the other, it would never be assumed that the portions discharged in America would flow by a return current back through the ocean to supply the other end; and the cases are precisely similar,—the earth acts the part of a reservoir with regard to electricity as much as the ocean does with regard to water; and the circumstances under which return currents either of water or electricity could be produced, would bear the same analogy to each other. The only benefit, then, which the present wire could confer, would be by improving to a certain extent the conducting character of the earth, or in other words, by increasing its capacity to receive the discharge, or afford the necessary supply. I am free to admit, however, that with the present wire the amount of assistance that would be afforded might be limited from its very inadequate conducting capacity. With a capacious insulated return wire, however, the case would be different. It would, as I stated in my last paper, lessen the amount of induction by decreasing resistance, and consequently obviating the necessity of employing currents of high tension; but it must not be inferred from this that inductive action would not take place at all. The two cables would, in fact, when carrying reverse currents, represent two Leyden jars oppositely charged, and with their outer coatings in conducting communication with each other, or as is actually the case, both uninsulated.

I have been led to the conclusion that an insulated return wire would be preferable to an earth-circuit. Induction between the two cables, it is true, cannot be prevented; but it will be much less, as I have already shown, with two separate cables than with two wires included in the same sheath. I have been thus explicit, because the tendency of some scientific discussions which have lately taken place has been rather unfavourable to the recognition of this principle; and whilst I would not dogmatically enforce my views, yet I think they would bear the test of trial.

The success of the foregoing plan, however, would be, after all, only palliating the evil without removing or mitigating the cause; and I would now therefore direct attention to a new form of cable, intended to reduce not only the amount of static inductive action on the dielectric, but the degree of disturbance produced by the residual static discharge.

Since resistance in wires requires the employment of intensity in currents to overcome it, it follows that the greater the intensity of the current, that is to say, the greater the amount of free statical electricity accompanying the dynamic current, the greater will be the tendency to charge the dielectric. Now any increase of charge on the dielectric will produce results in discharge as the squares of the quantities thus taken up. Upon this principle I propose to use a capacious conductor, which shall diminish resistance as much as possible, and thereby reduce correspondingly the intensity of the current requisite to work through it, and its tendency to charge the dielectric.

Since the quantity of charge which can be taken up by any dielectric will depend upon its thinness, or the contiguity of the conducting surfaces between which it is included, I propose to increase the thickness of the dielectric or insulating coating, and thereby not only still further reduce its tendency to charge, but increase its insulating faculty. There are, however, other conditions which interfere still more with the results of discharges from coated surfaces which have been hitherto overlooked, but which may nevertheless render essential service in their judicious application to the insulation of a submarine conductor.

If a Leyden jar or a coated glass plate have layers of paper or any other fibrous material inserted between either or both of its coatings and the glass, although the glass may, as far as the phenomena of tension or attraction are concerned, be charged to the same intensity, yet the effects of the discharge suffer an extraordinary diminution.

Without going into detail upon the results of each modification of the arrangement, it may be sufficient to state that, whilst with the ordinary tinfoil coatings a given effect was produced, only $\frac{1}{10}$th to $\frac{1}{100}$th of the effect was obtained when the porous layers were interposed; and this diminution of effect bore no apparent relation to the conducting or non-conducting character of these media.

Reasoning upon these results, it occurred to me that, in addition to the advantages before alluded to to be derived from increasing the thickness of the dielectric and the capacity of the conductor, still further benefit would result by adopting some modification of the foregoing arrangements in relation to the cable. The interposition of porous or fibrous media between the coatings and the jar or glass plate, reduces the effects of the discharge; and since it is the discharge, more than the charge, which produces the embarrassment of signals, it appears a fair deduction that any arrangement which will reduce the effect of this discharge, will to the same extent diminish the amount of mischievous influence.

* Abridged from a Paper read at the Plymouth Institution.

Digitized by Google

Four modes of carrying out the conditions of the foregoing experiments with regard to the cable, presented themselves. 1st. By inserting a porous layer between the dielectric and its inner coating (the wire), which could be done by covering the wire with cotton, silk, or worsted, or any fibrous substance, previously to coating with gutta-percha. 2nd. By putting a fibrous coating of this kind over the gutta-percha covering of a wire already insulated in the ordinary way, taking care, of course, to make this coating impervious to moisture. 3rd. By inserting the porous or fibrous media between the layers of gutta-percha; or 4th. By adopting two or more of these processes in conjunction with each other.

With regard to the first process, I found from actual experiment that when the conducting wire was very small, as, for instance, in the Atlantic cable, the application of a porous covering to it previously to the gutta-percha coating unduly increased its bulk in proportion to its original size, and thereby proportionally increased the inner charging surface of the gutta-percha. But even under the most unfavourable circumstances, when for the sake of experiment a double coating of fibrous material had been put on, and the inner surface of the gutta percha increased to nearly three times its original dimensions, whilst the thickness of the gutta-percha coating itself was less, thereby enabling it to take up more than double the amount of static charge, yet the effects of the discharge were no more than from the original surface in contact with the wire: so that if only the same amount of charge had been thrown in, less than half the original effect might have been expected.

Since however, according to the experiments with the glass plate, the porous material was equally effective on the outside, or between two plates, it would appear that the most eligible situation for the fibrous layer in the cable, would be either between the coatings of gutta-percha or externally to them; and I doubt not that in either of these situations it would act with the cable, as with the glass plates, in materially reducing the effects of the discharge.

There are also other considerations of a mechanical character which render these modifications of the arrangement preferable. I venture then to recommend, with considerable confidence, the adoption of this plan as a simple and efficient mode of greatly reducing—I will not go so far as to say entirely obviating—the embarrassing influences of the residual discharge.

In a word, a cable constructed upon the principles here laid down will possess the following electrical qualification, viz.—

Its conductor will be of ample dimensions, thereby reducing the tendency to produce static induction.

The dielectric or insulating coating will also, by its increased thickness, not only improve the insulation, but have a diminished capacity for taking up inductive charge; and, lastly, the insertion of the fibrous substance will go very far to obviate the mischievous effect of any amount of charge that may be taken up, since by analogous arrangements we find that from 80 to 90 per cent. of this influence may be intercepted.

I cannot close this paper without alluding to the mechanical advantages also possessed by this form of cable. It is well known that when the gutta-percha coating of a cable is subjected to great strain, small fissures, before imperceptible, gradually become apparent from the separation of surfaces between which there was previously a want of perfect cohesion, although without this strain the cohesion might have been sufficient for electrical insulation, and the fissures might not have been formed. I have no doubt that the Atlantic cable has suffered in this manner, since it had no provision for preventing the gutta-percha from stretching.

Propositions have lately been made to form the core in such a manner as to take all the strain; but independently of the most serious electrical objections to a conductor compounded of iron and copper, I venture to predict that whenever such a cable shall be subjected to the strain of passing over pulleys, the gutta-percha coating will separate into pieces and slide over its included conductor. The interposition, however, of flax or hemp strand, which is a very eligible material, and which may be either braided on or laid on in a very long twist between the layers of gutta-percha and incorporated with them, will communicate such an amount of mechanical strength to the insulating coating, that, in addition to its improved electrical character, it will be free from the disadvantages before alluded to when not thus protected. The specific gravity also of such a cable may be made, if necessary, extremely low.

When made of the requisite dimensions, it need not weigh more than 6 cwt. per mile in air, or 1 cwt. in water; and, from experiments made with a sample of an analogous construction, the breaking strain would be upwards of 17 cwt., or equivalent to between seventeen and twenty miles of its own length in water. It will be remembered that the Atlantic cable would not support three miles of its own length in water; and I question much if the integrity of the gutta-percha coating could be depended upon under the strain of a single mile.

These are considerations which, I would venture to submit, are of no mean importance, even when viewed apart from any electrical qualities, but which, when taken in connexion with those already described, appear to me to give to this form of cable a decided superiority over any form yet devised. I say nothing of any subsequent coating of wire, &c. for additional protection in exposed situations, when found to be necessary, as such an arrangement is as applicable to this form of cable as to any other.

TRIAL OF RUSSIAN DESPATCH VESSEL SOUKSSOU.

The Soukssou is one of two despatch vessels (built by Mr. Pitcher at Northfleet Dockyard) for the service of the Russian Government.

At the trial in the river Thames, on Saturday the 4th ult., the results obtained were of so satisfactory a nature that they will be interesting to all connected with marine engineering.

The machinery of the Soukssou, manufactured at the Steam Factory, Northfleet Dockyard, is on Harman's patent horizontal direct-acting principle, and was constructed and fitted on board under the superintendence of Mr. C. Sage, from drawings prepared by Mr. Edward A. J. Buckland. In these engines the cylinders and condensers are arranged horizontally athwartships; there are two piston rods to each engine affixed to a cross head working on suitable guides, from which the connecting rod returns to the crank pin through an opening or aperture cast in the condenser for that purpose. The whole of the pumps (which have india-rubber disc valves, with metal guards and seatings,) are worked from the before-mentioned cross head, and consequently have the same stroke as the pistons. The boiler of the Soukssou is of the multitubular description, with brass tubes; it has a fire-bar surface of 54 feet, and a total effective heating surface of 1246·1 square feet=20·77 square feet per N. H. P. The propeller is a double-thread left-handed screw of the dimensions given beneath. During the whole time of the trial there was an entire absence of vibration either in the engines or vessel, which in screw engines running at high velocities is unusual. Such a thing as a hot bearing did not occur during the trial.

The following is a summary of the principal dimensions, performance, &c.:—

Length on load water line	121 ft. 10 in.
Breadth on ,, ,, ...	20 ,, 3 ,,
Draught on trial (mean)	9 ,, 3¾ ,,
Tonnage, builder's measurement	269 tons
Displacement at time of trial	288·5
Area of immersed midship section	123·5 sq. feet
Nominal horse-power of engines	60
Indicated ,, ,, ...	253·7
Diameter of cylinders	28 inches
Length of stroke	15 ,,
Diameter of propeller	7 ft. 9 in.
Pitch of ditto	11 ,, 0 ,,
Length of ditto	0 ,, 19 ,,
Number of revolutions (mean)	110
Mean speed of ship, in knots per hour	10
ditto propeller, ,, ...	11·93
Slip of propeller, ,, ...	1·93
ditto per cent.	16·1
Nominal horse power to midship section ...	0·486
Indicated ,, ,, ...	2·054
Area of screw's disc to midship section ...	2·616
Co-efficient of locomotive duty by formula $\frac{\sqrt{3}a}{\text{I.H.P.}}$	486·8
Co-efficient by formula $\frac{\sqrt{3}a}{\text{N. H. P.}}$	2058·3
Weight on safety-valves in lbs. per square inch	20
Mean vacuum in condensers	25 inches
Mean steam pressure (at mile)	18 lb.
Quantity of coal on board at trial	38 tons

Digitized by Google

THE ATLANTIC TELEGRAPH CABLE: CAUSES OF FAILURE, AND PROBABILITIES OF ULTIMATE SUCCESS.*

Communicated by Lieut. MAURY, U.S.N., in a Letter to JOHN LOCKE, M.R.D.S.

"National Observatory, Washington, Dec. 1858.

"DEAR SIR,—Your letter of the 9th instant, with a printed slip containing suggestions with regard to lines of submarine telegraphs, has been received. Several persons have done me the honour to submit plans for laying telegraph wires across the sea. Most of these plans seem to be based on the supposition that the cable which now lies a mere rope along the telegraphic plateau, is the *kind* of cable to be used hereafter. This is a mistake; for the true nature of the *Neptunian* obstacles to the enterprise of 1857-58 have not, it appears to me, been rightly appreciated. I leave out of view for the present all questions relating to the electrical conditions of the problem, and address myself exclusively to the Neptunian difficulties with which the projectors of any line of telegraph across the Atlantic Ocean will have to contend; for, had the true nature and extent of these difficulties been properly considered by the London Company, I have no doubt but that the Atlantic Telegraph would at this day have been in successful operation.

"The system of deep-sea soundings which was inaugurated in the American navy about ten years ago, and in which the navies both of England and France have participated with signal success, has led to a series of discoveries of the highest importance to submarine telegraphy. The facts which these soundings have brought to light concerning the status of the deep sea are such that, when properly considered by the hydro-telegraphic engineer, will render lines of submarine telegraph as cheap, if not cheaper, than our overland lines are. A full account has been given of these discoveries in my work on the 'Physical Geography of the Sea,' and in the publications of this office, the most recent of which are contained in vol. i., 8th edition, 'Maury's Sailing Directions.'

"In stating these facts, and the results derived therefrom, let us in the first place confine our attention to 'blue water.' It is an established fact that there is no running water at the bottom of the deep sea. The agents which disturb the equilibrium of the sea, giving violence to its waves and force to its currents, all reside near or above its surface. None of them have their homes in its depths. These agents are, its inhabitants, the moon, the winds, evaporation, and precipitation, with changes of temperature—heating here and cooling there.

"The rays of the sun cannot penetrate into the depths of the ocean, and radiation cannot take place there; consequently, the change of temperature in the depths of the sea, from summer to winter and from winter to summer, must be almost if not entirely inappreciable. This is a generally admitted fact.

"The winds take up, in vapour, fresh water from the surface, and not from the depths; and in so doing they disturb the equilibrium of the water at the top, not the equilibrium of the water at the bottom: for by evaporation the surface water becomes salter and heavier than it was before. The vapour thus taken up is condensed into rain, and precipitated on other parts of the sea, thus raising the sea-level, and making the water lighter and less salt than it was before. Thus we have the genesis of a horizontal circulation, or an interchange of water, which we call currents. If by the process of evaporation the surface water becomes so salt as to be heavier than the water at the bottom, the water at the bottom and the water at the top will change places. This may give rise to a vertical circulation, but one so feeble that it cannot be felt by even the tiny little shells which strew the bed of the ocean, and which lie there as lightly as gossamer under the dew of the morning. Practically, therefore, the water at the bottom is still.

"It is also generally admitted that the waves, even in their most angry moods, are incapable of reaching far down in the sea, or of disturbing the quiet and repose which reign in its depths.

"In short, there is reason to believe that the bottom of the deep sea is everywhere protected from the violence of its waves, the abrading action of its currents, and the rage of the forces which are ever at play upon its surface, by a cushion of still water.

"The grounds for this belief are afforded by these circumstances:—Everywhere, whencesoever specimens of bottom have been obtained by the deep-sea plummet, they have been found to consist of the untriturated remains of the microscopic organism of the sea; some of these have the flesh of the little creatures still in them. Now these feculences of the sea, as the remains of its microscopic inhabitants may be called, are relatively as light in the water as motes in the air; and if the bottom of the deep sea were scoured by its currents, these *sea-motes* would be swept away into drifts like snow, or into dunes like sand. They would bear the marks of water-wear upon them; they would be scratched; their sharp corners and their edges would be broken off and rounded; moreover, were they drifted about, then sand and other scourings of the bottom would be found mixed with them. But not so: the specimens brought up from the deep sea show no such mixture, and the Infusoria thence bear no marks of abrasion upon even their most delicate parts. Indeed, some of them are so fresh, still having the meat of the animal in them, that Professor Ehrenberg of Berlin, with others of the '*Biotic*' school, maintains that these shells live at the bottom of the deep sea, whence the sounding-rod recovered them.

"The '*Anti-Biotics*,' on the contrary, maintain that these shells live and die at or near the surface, and are buried on the bottom and bed of the ocean; that the antiseptic properties of sea-water tend to prevent decay in the first instance, and, as the dead animalculæ continue to sink, the pressure of the superincumbent water prevents chemical decomposition; and consequently, they of this school hold, and rightly hold, I think, that so far from admitting that any of the abrading forces of water, which are so familiar to us, are harboured in the depths of the ocean, or that they can find room for play there—they maintain that the hand of decay itself becomes, when stretched forth in the chambers of the deep, so palsied as scarcely to be able to make itself felt, even upon the most perishable things there.

"The pressure upon the telegraphic plateau varies from 200 to 300 atmospheres; that is, from 430,000 to about 650,000 lb. the square foot. Chemical forces may be measured, and consequently overcome, by pressure; for the gases generated by chemical decomposition are themselves capable (so the chemists tell us) of exerting in the processes of that decomposition only so much pressure. Hence, if we subject them to a greater pressure, they cannot separate, and decomposition cannot take place. In proof of this, I refer you to a recent discovery by Ehrenberg. In the specimens obtained at a great depth from the Mediterranean, that celebrated microscopist has distinctly recognised fresh-water shells with meat in them.

"From this beautiful little fact we may infer that the very volatile gases which enter into composition for the formation of the fleshy parts of marine animalculæ are there subjected to such a pressure upon the bed of the ocean that they *cannot* separate. If this inference be correct—and it doubtless is—may we not proceed a step further, and conclude, with reason, that with the pressure of the deep sea upon it the gutta-percha used for insulating submarine wires becomes impervious to decay?

"With a due appreciation of these facts and circumstances, we are now prepared for the question which involves most of the *Neptunian* difficulties with which the Atlantic Telegraph Company has been contending with their cable; and the question (such being the facts) may be thus stated:—Is not any cable, that is heavy enough to sink, strong enough to lie on the bottom of the deep sea? If yea, then tell me why have any *Atlantic* 'CABLE' at all? Why serve gutta-percha cords at all for the deep sea with *iron wire*? I am not speaking of the shore-end, where the water is shallow, where abrading forces *do* work, and where the iron service is required; but, as I said, my remarks relate to the deep sea, and I speak of the cable for *that*.

"Of what use to the cable was that iron coat of mail in which the insulated conductor was encased? Was it to make the cable sink? Why, the company found the cable so heavy when they began to pay it out into the deep sea, that they were constrained to postpone the undertaking from 1857 to 1858, that they might tax the ingenuity of the world for brakes and paying-out machinery that would prevent the cable from parting by its own weight, when running out in deep water. Without the iron coating it was heavy enough to sink; and if it were not so, a little larger conducting wire in the centre would have made it so, without any *injury*, I apprehend, to the *electrical* capacity of the cord. Many have proposed buoys for the cable. What a simple substitute for buoys would it be to leave off the coating of iron wire! Had that been left off, there would have been no need of 'brakes'

* Paper read before the Royal Dublin Society.

Digitized by Google

and much other machinery that the cable required on account of its cumbrous coat of mail.

"Bearing in mind the quiet which reigns at the bottom of the deep sea; that the bed of the ocean is protected from the abrading action of its currents by a cushion of still water; that there is no running water down there, and that the pressure is such as to obstruct, if not for ever to prevent, the decomposition of all animal and vegetable matter when once lodged there,—let us inquire a little more minutely as to the use of that iron wrapping for the deep-sea part of the cable.

"It was not to protect the cable from abrasion after the cable was lodged on the bottom, for we have discovered that there are no abrading forces there to fret it.

"It could not have been to keep the cable down, for we have seen that the lightest dregs that float in the water are, when allowed to settle on the bottom of the deep sea, heavy enough and *strong* enough to remain there.

"It could not have been on the score of economy, for the cost of the cable must have been nearly, if not quite, doubled on account of the iron wrapping.

"The wrapping of iron wire without does not, I imagine, tend to *improve* the conducting powers of the copper wires within; and besides the cost and the difficulty of manipulation, owing to increase of both size and weight which this iron wrapping gives the cable, that increased size and weight have, I imagine, something to do with the real cause of the electrical difficulties of the cable. What the real nature of those difficulties is, must be matter of conjecture; but the conjecture which seems to me most plausible is one of this sort:—The conducting wire is a strand of seven copper threads twisted together. This strand is then coated with gutta-percha, making a straight cord about the size of a lady's finger. This cord is then served with eighteen strands of iron wire, consisting of seven threads each, wrapped spirally about it. Now, in the process of paying out in the deep sea, and in holding back, the strain of the two or three thousand pounds which was brought to bear upon the cable, in order to prevent it from running out too fast, was first borne principally by the straight cord, consisting of the gutta-percha and the conducting wire, rather than by the spirally laid iron wires.

To illustrate this proposition, namely, that the strain was brought to bear upon the straight centre-piece, or heart, as the conducting wire with its coating of gutta-percha may be called, rather than upon the spirally served iron wire, it is only necessary to refer to rigging on board ship that is laid up with a heart-piece or centre strand. The strands of the rope, like those of the iron wire, are laid spirally about the *heart*, and when the rope has been subjected to a strain, 'Jack,' to use his own language, always finds '*the life all gone out of the heart.*' Certainly, a spirally-laid rope yarn or iron wire will stretch more than the one about which it is so laid.

"Such was the strain brought by the brakes upon the cable on board the Niagara, says an eye-witness, that 'large quantities of tar are pressed out of the cable as it enters and leaves the machine, and fall into tubs which are left near the machine for its reception. Of this stuff a couple of ordinary sized barrels-full are collected each day, and thrown overboard.'*

"Here was force enough to impair insulation by stretching, indenting, and cutting the gutta-percha, or to injure conducting powers by stretching and breaking the threads of the copper wire; for as I said, when the Niagara and Agamemnon were paying out this cable last summer in the deep sea, and when the brakes were holding back with the strain of 2000 or 3000 lb. on the cable, the heart suffered first. The gutta-percha would outstretch the copper, and then each wire of the conductor, which consisted of seven small copper threads, was attacked in detail, and thus the strength of the conducting wire was often tried without any perceptible giving way. It was impossible to have the strain to come upon all the threads exactly alike; probably, therefore, first one parted, and then another; so that in the whole distance each one of the seven may have parted may times—sometimes one alone, sometimes several, perhaps all, or all but one or two at the same place; for the parting of any one facilitated the parting of the rest, and all at the same place. One conducting wire would have been better both in an economical, electrical, mechanical, and Neptunian point of view.

"At first the fractured surfaces, with their crystalline points, were bright, and the galvanic current could leap the little chasms with comparative facility; but use tarnished them, and the leaps became more and more difficult. Hence the passage of intelligible messages at first, and their gradual cessation, and the subsequent failure of the cable to give any signs of life. This, however is, as I said, mere matter of conjecture, but it is the most plausible explanation that I have heard as to 'why the cable has stopped working.'

"The first step, therefore, towards success in the establishment of submarine lines of telegraph across oceans is to get rid of the idea of iron ropes and great cables for the deep sea (limit these to shallow water), to divert ingenuity from brakes and buoys, and direct it to cords that will require neither. But some will say that the heat in a ship's hold is often such as to melt the gutta-percha, and therefore an iron wrapping is necessary to hold it together, and so preserve the insulation. The 'Rogers' cord' is a complete answer to this objection. After insulating, he braids the conducting wire, whip-cord fashion, with bobbin or twine, and then protects the whole with a pigment, gum, or cement, which shields the gutta-percha, securing it against chafes, bruises, melting, &c., and still leaves the cord so small and manipulable that one ship may carry the whole of it, and 'pay and go' with it across the Atlantic as fast as though she were making an ordinary passage.

"The specific gravity of this 'Rogers cord' is such as to carry it down at the rate of only a mile or two an hour. Now it is evident that pieces of such cord, if cut into lengths ten miles long, for instance, and thrown into the sea, would find their way to the bottom as readily as pieces of one mile, or of a few fathoms, in length would. And since, at the greatest speed of the paying-out vessel, not more than about ten miles of this cord will at any one time be beween the stern of the vessel and the bottom of the sea, the feat of laying it in lengths of ten miles may be practically accomplished by an artifice; and the artifice consists in paying out the cord with slack enough in every ten miles of it to feed the current, and to spare.

"The common operation of 'heaving the log' may be referred to in illustration of the manner in which the 'Rogers cord' may be laid. In heaving the log a certain quantity of what is called 'stray line' or 'slack' is always paid out. This new cord is not larger than a common log-line. And the line between Varna and Balaklava, which worked so well in the Black Sea, was, I have understood, paid out by hand. It was simply a copper wire, insulated with gutta-percha, and without any other covering. If such a wire could be laid in the Black Sea, one could be laid in the *deep* sea as well; for there is reason to believe that the currents of the ocean do not extend beyond a few hundred fathoms in its depths.

"There seems to be a sort of general impression that the amount of slack cable required to feed the currents of the sea is very considerable. A little reflection will show that this is not the case, especially along the telegraphic plateau.

"The current which requires the greatest proportion of slack is one which sweeps across the cable at right angles; whereas the great circle along which the Atlantic cable was laid crosses the Gulf Stream so obliquely, that practically a vessel running from Newfoundland to Ireland may be considered as running with that stream for much of the way.

"The current along the telegraphic plateau seldom exceeds two knots an hour; it rarely amounts to that. But to present the strongest case against the view I am advocating, let us suppose that the current there runs all the way across at the rate of two knots, and at right angles to the cable, and that a vessel, with the proper length of the Rogers' cord on board, were to set off, 'to pay and go' with it from Newfoundland to Ireland; the cord, being paid over with 10 per cent. of slack, is heavy enough to sink at the rate of two miles an hour. The current, let it be supposed, extends to the maximum depth of half a mile; any given part of the cord, therefore, as it goes out and sinks at the rate of two miles an hour, occupies fifteen minutes in sinking the first half mile. During these fifteen minutes only it is exposed to the current, by which it is swept half a mile to the right or the left of the track of the ship; then, reaching the still water below, it settles down through it until it reaches bottom.

"Thus in the case supposed the cord would lie, not in a zig-zag, but in a line all the way across, and only half a mile to the right or the left of the path actually made by the keel of the ship. The difference in distance by such a path and such a line would be practically unappreciable; and yet the case supposed is an exaggeration of the case that is actually presented. For a part,

* Mullany's 'Telegraphic Cable,' p. 264.

Digitized by Google

if not for the entire distance, there is an under current which would bring the cable back towards the direct line, thus tending to counteract the effect of the upper current in sweeping it off.

"In confirmation of these views, and of the existence of that cushion of still water at the bottom, I bring in for further evidence the testimony afforded by Commander Dayman, R.N., while running his line of deep-sea soundings along the telegraphic plateau in H.B.M.S. Cyclops.

"On one occasion he hauled up from the bottom a coil of 200 fathoms of deep-sea line; it had been laid at the bottom, round and round, in a coil, with as much regularity as it could have been coiled on deck by hand: thus showing that either there was no current there at all, or that the upper and under currents so nearly counterbalanced each other, that the line passed perpendicularly, or nearly so, through the still water.

"The tiny nautilus rides out the hurricane and weathers storms in which the stoutest men-of-war have foundered; and in order to make progress in submarine telegraphy, we must proceed upon the principle that *a slack line in the sea will hold longer than a taut cable*, for the forces of its waves and its currents are not to be overcome by such powers of resistance as human fabrics have the strength to offer.

"I have no doubt whatever as to the ultimate success of a telegraph across the Atlantic. Indeed, the only limit to our power to establish at pleasure lines of submarine telegraph is the limit, if any, which Nature herself may have imposed upon the galvanic current. The sea offers no obstructions on account of its depths or its currents to lines of any length. A line with an unbroken conducting wire across the Atlantic or the Pacific, is as practicable as one across the Alps or the Andes. In the long run, and mile for mile, I do not think there would be much, if any, difference as to cost between the two.

"*The real question for future projectors of lines of submarine telegraph is, not how deep, or how boisterous, or how wide the sea is, but what are the electrical limits to the length of submarine lines?*

"You know that England and France, Spain and Portugal, Holland and Denmark, Sweden and Norway, Russia and Prussia, Belgium, Austria, and the Holy See, Sardinia, the Republics of Bremen and America,—indeed, all the maritime states of Christendom,—have joined hands in a general system of research into the physics of the sea; and among the many valuable results which they have already given to the world, the discovery of a way for the lightnings through the chambers of the deep may be regarded not by any means as the least."

SIMPLE METHOD OF CALCULATING EARTHWORK.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

In your May number, A. S. W. describes a method of calculating the contents of cuttings, and asks if it has ever been previously used. I may inform you that the same method has been used by me for some years, but I never looked upon my application of it as a *discovery*, for I thought it would be sufficiently obvious to any person with a slight knowledge of mathematics, who might have frequent occasion to measure irregular solids.

The method was first suggested to me in 1846, when investigating the proper system of ascertaining the cubic contents of walls built to support the slopes of embankments. I was then engaged in forming reservoirs at Whittle Dean, for the water supply of Newcastle-upon-Tyne. The walls of our grating tanks were of the form shown in the two figures: Fig. 1 being an elevation of the wall, and Fig. 2 a section of the same at E.

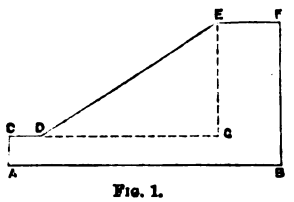


Fig. 1.



Fig. 2.

The upper surface of the walls, or where they coincided with the slope of the embankment, as on CDEF, was of uniform breadth, the face was perpendicular, and the back battering. In measuring the contents of the triangular portion DEG, it seemed at the first glance that a near approximation would be attained by multiplying the length DG, by half the height EG, and this again by an average thickness found by taking one-third of the sum of the thicknesses at the angles. I soon found that not an approximation only, but the exact contents was the result. Subsequent investigation showed me that this method was coincident with, and directly deducible from the prismoidal formula. For let us call a, b, and c, the thickness at D, E, and G respectively, l=the length DG; h=the height EG.

For wider application I take a different symbol for the thickness at each angle. Then "*the sum of the areas of the ends added to four times the area of the middle section, and multiplied by one-sixth of the length will give the contents.*"

$$\text{Area at D} = a \times o = o. \quad \text{Area at EG} = \frac{b+c}{2} h.$$

$$\text{Four times area of middle section} = 4 \times \tfrac{1}{2}\left(\frac{a+b}{2} + \frac{a+c}{2}\right)\frac{h}{2}$$

$$= \left(a + \frac{b+c}{2}\right)h$$

$$\text{Content} = \left[o + \left(a + \frac{b+c}{2}\right)h + \frac{b+c}{2} h\right] \times \frac{l}{o} = \frac{a+b+c}{3} \times \frac{lh}{2}$$

which last expression is the method of A. S. W.

The prismoidal formula admits of very wide application, and I find it useful in calculating the contents not only of cuttings, but of conic and pyramidal frustrums, and in various ways.

T. D. Ridley.

Hexham, May 10, 1859.

ON THE CONSTRUCTION OF DOMES.*

By T. Hayter Lewis.

Having some few years since to erect a dome of very considerable span, I was surprised to find how little practical information existed on the subject. Being thence led to investigate and to make notes relative to domical structures generally, I have now put them together, in the hope that others may also be induced to give the result of their experience and studies respecting this beautiful class of buildings—the most beautiful termination, it appears to me, for any grand architectural composition. In the present paper it would not be convenient to enter into elaborate mathematical investigations. I shall, therefore, merely refer to the principal theories on the subject; describe the construction and the cause of failure of some few of the most celebrated domes; and then try to sketch out some broad principle for adoption.

The theories best known are those of Dr. Robison, of Venturoli, and of Rondelet. Dr. Robison's was, I think, first published in his 'Mechanical Philosophy,' and then re-written by him under the article "Arch," for the 'Encyclopædia Britannica:' it has been referred to in almost every subsequent work on mechanics. From this theory, the particulars of which may be found in the works to which I have alluded, are deduced directly the following somewhat startling results:—that a dome starting from a perpendicular drum could not stand at all; and that a reversed curve is a much stronger form than the usual insistent one. Venturoli's theory is given by him in his 'Treatise on Mechanics,' a very good translation of which has been made by Mr. Creaswell. The results are very much the same as Dr. Robison's. Rondelet's theory is given in detail in his well known work on Construction, and it has been very well condensed in Gwilt's admirable Encyclopædia. It is of a much more practical nature than the others, and assumes that the weight of the upper part, pressing outwards, is counteracted by that of the lower part; the difference of the two forces giving, so to speak, the measure of weakness in the dome.

There is another theory to be found in the well known 'Parentalia,' but to which I should not here allude, were it not almost the only one mentioned in that work; and although it may now appear almost absurd, the author's extended notice of it would induce us to believe that it must have been favourably accepted in his time. It will be found given at considerable length in any edition of the 'Parentalia.' It refers, however, more particularly to arch construction.

Now, I have too great a reverence for the study of mathematics, and I am too sensible of the advantage that our profession derives from that science, to say one word that might appear to

* Paper read at the Royal Institute of British Architects.

Digitized by Google

slight it; and indeed, the great names I have mentioned would prevent my speaking so strongly as I am obliged to think of their theories, had I not found words as strong used by one of the most noted of the authors themselves, Dr. Robison. In one of the articles to which I have referred, he gives an analysis and description of the arch. He puts the theory before his readers in a perfect manner; shows how beautifully the exact size of every stone, and the curve of each arch can be calculated; and, in fact, leaves us quite satisfied that the theory is correct. Then, having made everything so clear, he quietly informs his readers in an equally clear manner that the speculations of all the eminent persons who have written upon it are of no practical value whatever. The fact is, that the most celebrated of these theories assume as a basis that the arch or dome is formed of layers of stone, sliding freely upon each other, without bond, friction, or the interposition of cement—conditions which never have occurred, and which never can occur in actual practice. Moreover, it is really for all practical purposes almost waste of time to deduce calculations for constructing stone domes at all; for, curious as it may seem, I believe that there is not existing, and that there never has been built, any stone dome of very large size, since the time of the Atridæ, at Mycenæ.

The construction we have to consider, if it is to be of any practical use, is of brick, and this material is so combined in execution with cement, that the theoretical joints do not really exist; for with good cement the bricks themselves are as likely to yield as any of the joints. In stone construction the case is different. The thinness of the mortar in the joints makes them really what their name implies, and we should consequently approach near to, though we can never actually realise the conditions of the theory.

Now, in addition to the difference in the materials, we must also remember that the details of construction in the domes now existing vary very much, and that they are by no means to be resolved by one theory. As I propose to notice actual examples only in this slight sketch, I must ask you to examine with me, briefly, the principles of construction of the most noted. The first to which I will allude is the celebrated tomb of the Atridæ, at Mycenæ. I need scarcely mention that it is formed of horizontal layers of stone, in large blocks worked to the form of the curve on the inside only, and without, so far as I am aware, any cement in the joints. It is of considerable size (48 ft. 6 in. in diameter), being about that of St. Vitale, at Ravenna, and somewhat larger than that of St. Stephen's, Walbrook. The construction displays great simplicity, and theoretically no power short of what would actually crush the very stones could, so far as I can see, break this dome. The pressure at every joint is perpendicular, so that there is really no outward thrust, and the tendency of each stone to fall inwards is met and destroyed by the opposite thrust of the other stones. If the task were now given to erect a dome of a pointed vertical section, with large masses of stone, such as the architects used of old, I doubt if a better mode of accomplishing it could be found.

The next examples are those of the well known Pantheon (142 feet diameter) and of the Temple of Minerva Medica (81 feet diameter); baths or temples, as you will. These domes are formed of several ribs of brick, which appear to have been built quite distinct from the filling-in work between them; just as in early Gothic vaulting the various ribs were first formed and set in their place, and then the intermediate light chalk panels added to complete the whole. This opinion as to its construction is confirmed to a certain extent by the way in which we know, to our regret, that the dome of the so-called Minerva Medica has perished. But a few years ago the ribs stood firmly, although a great part of the filling-in between them had disappeared. I believe the same might occur at the Pantheon, and that its skeleton construction is just that of York Chapter-house; so that, without at all altering the leading principles, we might arch the filling-in to steady the ribs, and convert the great dome of the Pantheon into a gigantic resemblance to its graceful little English rival. Whether or not the change would be approved, it is not for me to surmise; but that the vast building would at once display as it never has displayed its enormous size, I have no doubt whatever. Setting however this question aside, it seems to me, that in this greatest and noblest of domes we have the essentially Gothic principle of security by abutment, and not by a tie; for if, as I believe, the stress be borne by the great ribs, the tie to be effectual must clearly be straight from one of them to the other: otherwise, if we put it in the circular form the feet of the ribs would spread outwards until the tie became straightened. But if we fill up the space between the ribs, this filling-in would serve to strut them, and preventing by its circular form the tie from straightening may occasion it to act. If therefore in the Pantheon dome there be any real binding courses, I believe that they act as ties to the ribs only by the filling-in acting as strutting. But I do not believe that the tie exists at all, but that the stability of the dome is secured by the strong abutment only.

The next example is the dome of St. Sophia, at Constantinople, of about 110 feet diameter. Of this we have ample information, beginning with the history of the building so beautifully condensed by Gibbon, down to the recent elaborate drawings and description of Salzenberg. Unfortunately the ancient accounts, so clear and precise, are erroneous in one important particular; for while all state that the dome was finally reconstructed as it stands of pumice stone, or light Rhodian bricks, Salzenberg informs us that no trace of these can be found, and that it is formed altogether of ordinary well-burnt bricks. It appears that the four great piers at the angles of the square on the plan were the only supports at first adopted, and that the pendentives and dome were formed on them. The pressure of the eastern and western arches springing from the great pier was resisted by four walls forming transepts running north and south: against the eastern and western walls respectively abutted two semi-domes. The superstructure having given way towards the east, taking away the semi-dome on that side, the eastern pillars were strengthened, and the dome was again turned, but it gave way again before it was completed. Strong buttresses were then built to the east, and a dome (this time of pumice stone) turned for the third time. But it became cracked and split, the arches under being so fractured that those on the north and south sides required to be filled in with the three-storied arcades now forming such prominent features in the interior. This dome then stood awhile; but it was destroyed by an earthquake, and was subsequently rebuilt.

All this narrative would show that the substructure was the defective part, the great arches not having sufficient abutment; and that whether the dome as first built would have stood or not, not one, however sound in itself, would have stood upon such a base. Whether constructed of pumice stone or of light or heavy bricks, the recent dome seems to be of homogeneous construction, without separate ribs; answering in fact to our ordinary idea of a dome, as typified by the internal brick dome of our own St. Paul's. The general thickness varies from about 2 feet to 2 ft. 6 in. It has strong buttresses as abutments (8 ft. 6 in. thick) above the springing, and the walls under are excessively thick as compared with the thickness of the vaulting.

The next example is the dome at Beejapore. It is formed of a solid mass of brickwork, put together with good mortar: it is 124 feet in diameter, and varies in thickness from 10 ft. 6 in. at a little above the springing, to 10 feet near the top; so that it is four times as thick as that of St. Sophia, with a diameter one-eighth larger. I have few data from which to form an idea of the strength of the material, but I assume the general construction to be on the same principle as that of St. Sophia, but differing from it in weight, thickness, and bearings.

The dome of the Cathedral of Florence is 138 ft. 6 in. diameter, octagonal in plan, with a great rib at each angle, and two smaller ones on each face. These are connected together by a thin casing (about 2 feet thick) outside, and a thicker one (averaging about 7 feet) inside, with tiers of arches turned between the ribs in order to strengthen these casings. At the foot of the dome is a strong tie, composed partly of timber and partly of iron; and the whole mass rises clear above all the surrounding parts of the edifice, showing that the dome is quite self-supporting, and that it derives no strength from external abutments of any sort. It supports a heavy ornamental lantern; being the first great example in which this weight, extraneous to that of the dome itself, has to be supported. Some settlements appeared soon after its erection, but the whole seems to have stood without any serious defect until the end of the seventeenth century, when several fractures appeared for the first time, or were then considerably increased: they are said to have extended through the whole thickness of the dome, to have descended also through the tambour to the main arches, and thence in a clearly traced line down to the ground. It was therefore the opinion of some that the foundations only were in fault; whilst others considered that the dome had opened from lateral extension, thereby burst-

Digitized by Google

ing open the tambour, &c., and that it should be encircled by iron ties to prevent further spread. Fontana was of this opinion, and his advice being adopted, three iron ties were prepared; however, before they were completed, the contrary opinion (advocated chiefly by Nelli) prevailed: the ties were not fixed, and the fractures were merely secured by dovetailed cramps. The present stability of the dome proves that this remedy was effectual.

The dome of St. Peter's, the design of Michael Angelo, though carried out by Fontana, is about 139 feet in diameter, and differs from that of Brunelleschi just described, by being circular instead of octagonal on plan; but like it is formed of sixteen ribs, united together by a double casing, the outer about 2 ft. 10 in. thick in the centre, and the inner 6 feet thick. It stands on a tambour, without abutment at the springing; but a little below it is encircled by a peristyle, not however of mass enough to act in any great degree as a buttress to counteract the spread of the dome; and at the top of all is a heavy lantern. The dome is built of brickwork. Four ties were first inserted, at different heights. These proved ineffectual, the dome becoming very much fractured; and in 1743 two others were added, encircling the tambour and peristyle below the springing. The next year three others were added round the exterior of the dome; one near the top, a second half-way down, and the third at the foot. In 1748 another tie was put round it at some distance above the springing; and this is, I believe the last addition, the dome having appeared to be secure since that time. If my theory of dome construction be correct, this tie is the only one required.

I come now to the important question of the double wall or casing of this and of the Florentine dome. I scarcely know the general idea respecting this system of dome construction, but so far as I have been enabled to ascertain, it seems to be considered a method of obtaining strength by a clever arrangement of the material; much in the same way as we obtain it by casting a given amount of metal into a large hollow column instead of a small solid one.

Now let us try how these domes could be broken, and we shall then get some clue towards calculating their strength. Taking any one part separately it might be bent or broken horizontally, as a bow might be; or it might be similarly broken in its perpendicular section by the weight of the lantern pressing on the top, whilst the bottom was secured by an abutment or tie. This weight would act upon and be resisted by the perpendicular section, in the same manner as in the large boxed iron cranes now used in the docks, &c. For, if we may apply to these magnificent domes so homely an illustration, we may consider each pair of two ribs composing them, with the casings between, as huge bent tubular girders, of almost the same outline as those forming the dock cranes.

Now, any force that we can conceive likely to act as destructive to the dome, would produce a strain on the outer flange or casing tending to tear it asunder, whilst it would endeavour to compress or crush the inner one; we should therefore expect to find (supposing that the great architects who designed these domes adopted the hollow walling for strength) that they had arranged them as we should arrange the metal in a girder, distributing it in different amounts, in proportion to the forces that they have to resist. It is clear, however, that this was not the idea of Brunelleschi, or of Michael Angelo; for the external casing of their domes had no provision for resisting extension, whilst the materials of the internal vaults appear from their thickness to be intended to resist direct compression only.

I know of no other way in which the double vault could be used so as to give strength. It could not be with the notion of obtaining it as we do in a square hollow column; because a direct strain, perpendicular throughout to the direction of its length (an element necessary to the stability of a column) could not be brought upon it. It would, in fact, give way in the curve, as a bow would when pressed at the ends.

Brunelleschi's own description, as recorded by Vasari, seems to give us clearly his idea of the whole, and to show that his plan was to obtain the necessary strength by the ribs, and not at all by the double vaulting. He states that the external vault is necessary in order to protect the inner one from the weather; and he directs that the latter, after it has been raised to a certain height, should be formed of the lightest materials that could be found, whilst the ribs were to be built up throughout of solid stone.

I apprehend therefore, looking at the whole question, that Brunelleschi's idea was to construct the ribs of a certain form and thickness, and then to fill in between these ribs, so as to stiffen them and complete the vault inside and out; leaving a hollow space between, in order to lessen the weight as much as possible. The inside casing both at Florence and at Rome is made the thickest, as it has to bear to some extent the strain of the ties.

We have in England a beautiful example of the way in which stone ribs will stand when the rest of the vaulting has fallen, in the picturesque ruins of Mayfield, one of the most interesting remains in our southern counties. The whole of the ceiling, whatever it may have been, has disappeared, but the ribs still span the width of the great hall strongly and boldly; and with a few cross arches to steady them, and take the strain of the ties, I believe that the grand stone ribs of Brunelleschi's skeleton would do the same.

The last example I shall quote is the dome of our own St. Paul's; the first, I believe, of its type, but the general system of construction of which has been followed ever since. I do not wonder at its being thus copied; for the majestic effect gained in it by its architect has never been surpassed, and the whole composition of the exterior, at least, is to me the most glorious specimen of Italian architecture.

There is no direct abutment to sustain the thrust of its cone, which, contained by its tie, and held together by the general goodness of the work, stands firmly upon the tambour, without exerting any expansive force. I believe that in this cone we have the true secret of domical construction, which shows itself here in its simplest form, unconcealed by the curved outlines which in other cases mask while they adorn the reality. Secure this cone at the foot, and I know of no power that would break it, short of what would crush its materials to powder. Bend the straightness of its side into a curve, so as to enlarge it to the form of a dome, and as the curvature is increased the strength is lessened. Where would this curved dome break? Clearly, if it were weighted at top, and the foot kept from spreading, it would break like a bow, between the two points. Tie in this weak part, and the danger at that part disappears, being transferred to two other points between them.

In this view it will be seen that I look upon the fabric as being necessarily secured by a system of ties; and that it is not to be safely trusted to the independent spirit of its own construction. Assuming however this latter notion to be correct (as undoubtedly it is in theory), and that each particular ring of the dome is, by the goodness of the bond and the strength of the materials, strong enough to resist the pressure tending to burst it outwards, we might suppose that it would be self-dependent, and safe, without any extraneous guard of iron or other tie. But I apprehend that in practice this construction would be decidedly unsafe. Doubtless a vault of good brickwork laid in cement would be strong enough to resist any strain that the weight of a dome above could bring upon it, for we know its strength to be such that it is uncertain whether the bricks or the joints would break first, but in practice it is not safe to trust to this extent; strong as the work may be, the slightest yielding in the foundations will cause an unequal bearing in the weight above, and in a moment rend the strongest work. We may indeed imagine that a dome on a small scale may be formed of materials so strong and yet so light as to be effectively of one piece only, as though cut out of a solid block of stone, as is the Tomb of Theodoric, at Ravenna, or formed in one piece like a reversed cup; and in such a structure, no doubt, from the extreme tenuity yet strength of its substance, no ordinary rules for estimating the strength will apply.

Such also may be, and probably is, the case with such small semi-domes, for instance, as have been put up by my friend Mr. Scoles. One of them has a diameter of 30 feet, and is formed of four courses of plain tiles in cement, altogether 4½ inches thick. I believe that no failure has occurred in this kind of construction, which I have in my own practice also found to succeed very well. The strength in fact of this kind of work is so great, while its weight is so little, that it would perhaps render the fabric independent, to some extent, of a failure in the foundations, and unless it were heavily loaded in some particular part, would require scarcely any abutment or tie. Certainly this may and does suffice for small works; but if we extend the size we shall find the plan a somewhat dangerous one. We may strengthen the vault—put two feet of thickness where theory tells that one will suffice—and so trust our theoretically self-tied unbuttressed dome to stand as the great ones of old have stood. But in adding to its strength we

Digitized by Google

shall have doubled its weight; and should the carefully secured foundations yield only half a hair's breadth to this weight; should a little spring but carry away, gradually and unnoted, grain upon grain of the sand on which the massy piers of the dome may rest, soon will come the inevitable settlement, and our massive dome will rend and break away as though an earthquake had rocked it, and the more certainly in proportion to its very massiveness. Send but a single fracture through the thickness of the vault, and its sef-tied structure is resolved into two or more separate parts; therefore, although I do not doubt that a dome may be made so strong and so compacted as to need no extraneous tie, yet the risk of fracture is so great that we ought not to depend upon the safety of such construction only, but insure for it such an abutment as may resist thrust, or such a tie as shall be free to some extent from the risk of fracture from the pressure of the mass above, in case a settlement should cause the latter to press unequally.

One instance, indeed, the well known one of St. Vitale, at Ravenna, exists, in which the construction is so arranged as apparently to provide against the necessity of any extraneous aid. The dome is formed of a triple coil of earthen jars, the end of each being socketted into the top of the one adjoining in a very ingenious way, so that it seems to me that if a settlement were to occur in the substructure, this peculiar arrangement would allow of a slight re-adjustment of the coils without destroying their connection. The only guard against the outward thrust is, so far as I am aware, the weight of the walls above the springing; and, altogether, this dome appears a very fine piece of construction, and worthy of a close and detailed investigation. In fact, I know of no other existing which combines all the qualities of strength, lightness, and flexibility, without the aid of any extraneous tie; but it has not to bear the great weight of the lantern which presses so heavily on the Florentine, Roman, and London dome; and I should hesitate to speak too confidently of its capacity to bear it, even if its outline were raised to that of a pointed arch.

Passing then this example by as one of doubtful authority, and looking only on the form of dome construction most usually adopted, and supposing its work to be good and solid, there will be little principle of the arch involved in its construction, whilst it might in fact be built up in a solid mass, like the arched rib made by the elder Brunel some years back, by building it out from each side of a pier so as to maintain the equilibrium of the two half arches. We know that he proceeded with the construction till each semi-arch overhung 60 feet, and if the corresponding half had been carried out, the two together would apparently have formed one arch of 120 feet span; in the same way that two raking pieces of timber would form an arch by abutting against each other.

Now, how should we break one of these curved ribs, assuming it to be secured at the bottom, and loaded at the top with the heavy weight of the lantern? I apprehend that it would snap at the lower part of the bend, and at that point therefore we should want the tie; if secured there, any weakness would be felt at an intermediate part of the curve. But supposing that instead of a curve beam we had an angular one, and that it was carefully secured at the angle, it is obvious that we should have the form of the Mansard roof alluded to by Dr. Robison; and I know of no power that could break it, short of actually crushing it. Now we have this condition actually fulfilled in the cone of St. Paul's, which, so long as the tie exists, may be considered indestructible; let us therefore take this as a starting point, and going one step further, suppose that Wren wished to make, as Brunelleschi did, the shell of the fabric form its outline, inside and out, instead of concealing it as in St. Paul's.

Add any form of curve we like, the cone itself would still remain as the great constructive skeleton, to which any superadded mass would serve only as a clothing I believe that this is the real secret of constructing domes whose size exceeds the safe limits of a brick or other beam, and that we ought to make such domes approach so closely to the conical form that their section should include that powerful outline within their thickness.

I do not say that a great dome cannot be safely erected with other outlines, because by careful attention to the goodness of the materials, and to the general bind of the work, it may, no doubt, be made secure. But I believe the form above mentioned to be the safest, and that any departure from it entails risk. To test the correctness of this opinion as far as possible, I have applied the form to the sections of the domes of the Pantheon, of St. Peter's, and of the Cathedral at Florence, with the following results:—In the Pantheon a cone of 2 feet thick (about 6 inches thicker than that of our St. Paul's), is contained in the curved surface from the horizontal line at top to the abutment. In the Florentine example a cone of much greater thickness is contained within the curved section from the foot of the lantern to the tie orignally inserted by Brunelleschi, and never added to since. In St. Peter's a cone of similar thickness is contained in the curved section from the bottom of the lantern to the tie last put in, since which time no other has been, I believe, required. The rule bears of course upon one particular class of domes, in which a top mass of great weight has to be borne independently of the fabric itself.

There are, however, other cases in which this conical form does not obtain; but in these, so far as I am aware, the weight of the lantern is wanting, so that the curve has only the weight of its own section to sustain. Such are the domes of St. Sophia at Constantinople, and the celebrated one at Beejapore. Having no personal knowledge of the Indian domes, I speak of this last example with much diffidence, but judging from Mr. Fergusson's excellent description, I should say that the enormous thickness of this well-compacted roof renders it, as it were, equivalent to being cut out of one solid stone. I am the more satisfied that this is a correct idea respecting these domes, because it is stated that in some of them, though the foundations have given way, the domes are left intact. I shall, however, assume it to be composed of somewhat inferior materials, so as to render the outline of consequence to ensure stability.

In these flat-topped domes we have to provide both against the weight of the mass and the extra weight after every snow storm; and although this is not likely to demand the precaution of the single cone, still the conic principle modified must, I think, be carried out; and we must provide against the strains as we should in a Mansard roof, by inserting a tie at the base of each cone (answering to the roof strut) varying in strength in proportion to the angle and the weight. But it is clear that there is a limit to the angle, beyond which it would not be practically safe to trust to the cone, and for reasons too long to mention, I think that 40 degrees with the horizon should be the limit. Beyond this upper cone there remains an almost horizontally flat portion (seen most clearly in the example at Beejapore) of such evident weakness, that Brunelleschi was of opinion that it could not be strengthened sufficiently to bear the weight of a lantern, and for this reason he gave his dome the section of a pointed arch. It is undoubtedly weak; and cannot be treated in the same way as the lower parts. Let us suppose a solid ring at the top of the cone, leaving an opening as at the Pantheon. So far it will be safe. We have now to fill in this space with brick or stone work capable of bearing the superincumbent weight; and this filling-in must, I think, be considered as a solid curved beam, cut out of a mass, and strutted well at the abutments, conditions requiring no great strength where there is no lantern.

In conclusion, I would briefly recapitulate my opinion respecting the construction of domes.

I consider that the essential element of strength in a dome is a straight cone (whether simple in one unbroken length, or compound in two or more lengths) comprised within the section of its vaulted covering. That the base of each cone must be securely tied. That although, for the same reason as in ordinary walling, we ought to secure by bonding and perfect bedding this vaulted covering in every part, yet, with good materials and work, these ties at the base of the cone are the only ones theoretically required. That the strength of such ties at any part is to be found by resolving the weight, by the ordinary resolution of forces, into the lateral pressure at that part. That in domes with heavy weights at the apex the straight cone is the only safe one to adopt. That the vault may be made strong enough by ribs alone, and that when these ribs are required not to project beyond the general face line, inside or outside, double vaulting as at Florence and at St. Peter's may be safely used, but only as a means of lightening the weight. That although, by goodness of the work, domes may be erected strong enough to bear any amount of weight without any extraneous tie, yet that such tie should be always inserted as though the ribs were quite separate, in order to guard against settlements. Lastly, that the thickness of dome will be sufficient if it include within its section a cone, necessary to bear the weight.

Though believing these views to be correct, it is with conside-

Digitized by Google

rable diffidence that I put them forward, as they are, I have reason to think, opposed to those entertained by some who are well qualified to form a judgment on the subject, which is indeed one not to be entered on lightly. No one can forget the sense of solemn awe with which he has viewed the gigantic vaults of which I have spoken: for my own part, when engaged in investigating the secret of their build, in laying bare as it were the skeletons of these great works, and touching at every turn the memorials of such men as Brunelleschi, Michael Angelo, and Wren, there arises with the ordinary methodical calculations respecting strength and materials a strange feeling of reverence for the works we have been examining, and of distrust of my own ability properly to comprehend them.

A NOTE ON THE BINOMIAL THEOREM.

By Arthur Cohen, B.A., Magd. Coll. Camb.

I assume that the Binomial Theorem has been proved for positive integer exponents, so that supposing m and n to be positive integers, we have

$$(1+x)^m = 1+mx+m\frac{m-1}{2}x^2+m\frac{(m-1)(m-2)}{2.3}x^3+\ldots \quad \ldots (1)$$

$$(1+x)^n = 1+nx+n\frac{n-1}{2}x^2+n\frac{(n-1)(n-2)}{2.3}x^3+\ldots \quad \ldots (2)$$

But $(1+x)^m.(1+x)^n=(1+x)^{m+n}$. Hence the product of the series which form the right-hand members of (1) and (2) must equal $(1+x)^{m+n}$; that is

$$\left.\begin{aligned} 1+(m+n)x+\frac{(m+n)(m+n-1)}{2}x^2+\frac{(m+n)(m+n-1)(m+n-2)}{2.3}x^3+\ldots \\ = (1+mx+m\frac{m-1}{2}x^2+\ldots)(1+nx+n\frac{n-1}{2}x^2+\ldots) \end{aligned}\right\} (3)$$

It is then usual to assume that the product of the two series which occur on the right-hand side of the last equation must be of the same form, whatever m and n may be.

That this assumption is unwarrantable may however be easily shown. Take for instance the expression

$$m\cos(2\pi m)\times n\cos(2\pi n)$$

This equals mn when m and n are integers, but *not* when m and n are fractional.

That however which one has no right thus to assume may be proved in the following manner:

It is an elementary proposition in the Theory of Equations, that if a rational integral function of the rth degree is equal to zero for more than r values of the variable, it is identically equal to zero. From this it follows that if two rational integral functions of m of the rth degree are equal to one another for more than r values of m, they are identically equal to one another.

Let then $f(m,n)$ and $\phi(m,n)$ be two integral rational functions of m and n of the rth degree with respect to m and of the rth degree with respect to n, and let $f(m,n)=\phi(m,n)$ for all integer values of m and n. It follows that the coefficients of the powers of m in $f(m,n)$ must be equal to the coefficients of the like powers of m in $\phi(m,n)$ for all integer values of n, and as those coefficients are rational integral functions of n, it follows that those respective coefficients must be identical with one another, and therefore that the two functions are identical with one another, and that they are equal to one another for *all* possible values of m and n.

Let us now apply the above to the product of the two series

$$1+mx+m\frac{m-1}{2}x^2+\ldots, \text{ and } 1+nx+n\frac{n-1}{2}x^2\ldots$$

The coefficient of x^r in the product will clearly be a rational and integral function of m and n of the rth degree with respect to m and to n. Since then such coefficient is for all integer values of m and n known to be equal to

$$\frac{(m+n)(m+n-1)\ldots\ldots(m+n-r+1)}{2\ldots\ldots r},$$

it follows that such coefficient is *identically* equal to the latter expression, and therefore equation (3) is identically true.

I have thus filled up the gap which is usually left in what is known by the name of Euler's Proof of the Binomial Theorem.

BREAKWATERS
AT
DOVER, ALDERNEY, PLYMOUTH, AND PORTLAND.*

(*With Engravings.*)

Breakwater structures have generally been divided into two classes; one known as the 'long slope' section, of which the Plymouth breakwater may be taken as an example; and the other, the 'vertical wall' section, of which form the new pier at Dover is an illustration; the works at Alderney, and the inner breakwater at Portland, being a combination of the two.

The Plymouth breakwater, as is well known, was of these the first in order of time; it consists of a large mass of stone, deposited on the site of the work and exposed to the action of the sea, which, after the occurrence of gales of wind, has caused the surface to assume a certain determinate form, as it always does under such circumstances. In the case of the Plymouth breakwater, an additional mass or foreshore has been placed on the seaward side, in order to diminish the force of the sea upon the inner or main work.

A breakwater of this sectional form is admissible only in those cases where stone is abundant, and where it can be procured in large sizes; the quantity requisite for a given length and depth of water being much greater than in any other section. It should be observed, moreover, that the amount of material required for a work of this description will depend in a very great degree upon the range of tide at the site where it may be adopted. This arises from the fact, that within the limits of the tidal range, the sea invariably disposes of the materials in the form of a long flat slope. In exposed situations this slope is seldom or never of a steeper inclination than five feet horizontal to one foot perpendicular, and sometimes even flatter than this. Under the level of low water spring tides there is also, under similar circumstances, a flat slope, having generally an inclination of about four or five to one, this extends from low water of lowest tides, down to about twelve or fifteen feet under that level; from this depth to the bottom,—however deep the water,—the inclination is of a much steeper character, varying but slightly from the angle which the same materials would assume if allowed to roll over a bank above water. This arrangement of the materials by the action of the sea is exemplified in the sections of Alderney, Plymouth, and Portland, and a similar state of things invariably occurs under analagous circumstances.

Although the sea face of the new work at Dover is not strictly vertical, the general character of the section is such that it may be regarded as an illustration of the vertical-wall system. In works of this class the quantity of material employed is assumed to be reduced to a minimum, in which respect they differ essentially from those on the long-slope system; the former has, consequently, been adopted in cases where there is a want of suitable materials in the locality, and the latter where stone of proper quality is abundant.

As we have stated the breakwater at Alderney, and the inner breakwater at Portland, are instances of the combination of the long-slope and vertical-wall systems. After the description we have just given of these systems, it would seem to be unnecessary to do more than refer to the cross-sections, an inspection of which will show all the essential features of the works which they represent (see Plate).

For many years a great difference of opinion existed among engineers and scientific men as to the relative advantages and disadvantages of the long-slope and vertical-wall systems, many authorities insisting upon the theory that in the case of a vertical wall rising from the bottom in deep water, the wave is a simple undulation, and that it would rise up against a vertical face and act by its statical pressure only; whereas in the case of the adoption of the long slope, the character of the wave would be so completely and entirely changed that it would have a considerable amount of progressive motion imparted to it, and consequently great percussive force, the result being that the whole weight of the mass of water multiplied by the velocity with which it was moving would be the measure of the force exerted on the slope.

On the other hand it has been urged by eminent men, that so far from the sloping form of breakwater creating the force with which the wave rushes up the slope, it is owing to this force of the wave being permitted to expend and exhaust itself that the effect upon the structure in a horizontal direction is diminished;

* From the Supplementary Report of the Harbours of Refuge Commissioners.

Digitized by Google

these authorities asserting that the same force will act wholly like a ram upon the perpendicular wall, tending thereby to overthrow it. Many arguments were advanced in support of these conflicting opinions, especially about the period of the inquiry by the commission on the proposed harbour of refuge in Dover bay, in 1845-6.

Having endeavoured to give as concisely as possible the principal arguments advanced in support of both systems by their respective advocates, we should state that our own views of the *theoretical* part of this subject are in accordance with the opinions of those who, like the majority of the commissioners of 1846, approve of the upright wall. We base our opinions upon the now generally admitted conclusion that even in the heaviest gales the disturbing effect of the wave is but very slight at comparatively small depths below the surface, and that the character of the wave in deep water is essentially different from that which it assumes when influenced by the friction which arises from the ground in shallow water. A valuable paper on the subject of waves, by Mr. J. Scott Russell, will be found in the report of the British Association for the Advancement of Science, for the year 1844. Among other results arrived at by the accurate experiments and observations of that gentleman, it was found that in comparatively deep water the waves are formed by a movement which is little more than a rising and falling of the particles near the surface, which surface '*oscillates* above and below the level of repose,' these are described as 'oscillating waves;' whilst in shallow depths the motion is onward and progressive, consisting of a 'translation of the whole mass of fluid from one place to another,' the waves in this case are called 'waves of translation;' one important law deduced from these observations being that as the waves approach the shore they begin to break whenever they reach a point where their height becomes about equal to the depth of the water in which they they are moving. The report states that 'at a great distance from the shore, or where the shores are deep and abrupt, a body floating near the surface is alternately carried forward and backward by the waves, neither is the water affected to a great depth; whereas nearer the shore the whole action of the wave is inward, and the force extends to the bottom of the water.'

Whilst these results are in accordance with general experience, it may be well to remark, that the height and character of the wave and the depth of water in which it will break are greatly influenced by the existence of a current or stream, whether tidal or otherwise, as observation and experience have shown that in those cases where there is a current or stream moving in *opposition to* the direction in which the waves are travelling, their height and force is greatly increased beyond what they would have been had no such current existed; whereas, in the case of a current moving *in the same direction* as the travel of the waves, their height and force is diminished. The character of the waves, and the depths in which they will break, will also be modified by any sudden or material changes in the depth of water, or in the form of the shores or the bed of a bay or channel in which they may be moving.

Those who have observed the waves on the coast in the English Channel or German Ocean, have described them as attaining varying heights, but there is a general agreement to the effect that the height ranges between 12 and 15 feet in heavy gales of wind. Observation has also shown that, as a general rule, the waves in heavy on-shore gales begin to assume a broken character, and to attain great force on reaching those points where the depth of water becomes reduced to about 2 or 3 fathoms, which depth would be about the height of the waves in such gales, thus confirming the conclusions arrived at from the observations and experiments already referred to.

Though the deductions from these careful experiments would appear to be confirmed by general observation, we have been led to the conclusions which we shall presently describe, almost entirely by the practical results exhibited at those breakwaters the substructures of which have been formed by a mass of rubble allowed to assume any form that may result from the action of the waves. It is remarkable and at the same time important to observe, that in all works of this class the seaward slope invariably assumes a distinct change of inclination at some comparatively small depth below low water; this depth being 15 feet at Alderney, 8 to 10 feet at Plymouth, and 12 feet at Portland; the same general result is found to exist at Holyhead, Kingstown, and Cherbourg, and considering the difference in the size and form of the materials employed, and the exposure of the different sites, the uniformity is striking. From these facts the conclusion becomes inevitable, that the scouring action of the heaviest waves will not extend below a depth of 12 to 15 feet in any ordinarliy exposed situation on our coast, or at any rate, that there will be no action sufficient to disturb the rough stone of the sizes usually employed in works of this description.

Having regard to these facts, we are of opinion that the section advisable to adopt in many cases will be that which consists of a base formed of rough stone of various sizes, rising from the bottom to the level of 12 or 15 feet under low water of spring tides, founding thereon a structure of masonry, with a vertical face on the seaward side, extending so far above high-water mark as may be considered advisable under the circumstances. This masonry need not extend through the whole breadth of the work, but may be backed up with rough rubble stone, in order to give sufficient weight to the structure, the face on the harbour side being finished in any manner that may be considered expedient, having reference to the requirements of each particular case. Although the first cost of a work in the form of a section here described may be somewhat greater than that of one in which the masonry is founded on a rubble mound at the level of low water, we conceive that it would be less exposed to damage from heavy seas, inasmuch as the base would not reach so near to the surface as to cause the waves to assume a forward or progressive motion, even in the heaviest gales, and the work would consequently not be exposed to the heavy impact due to waves of 'translation.'

It would manifestly be injudicious to attempt to devise any particular form of section which should be applicable to all cases; we therefore wish to direct attention to the opinion that the form just described is that which we believe to be advisable in the majority of instances; but not invariably so, inasmuch as the particular circumstances of each locality must always have an important bearing upon the decision in this respect. The entire absence of suitable materials in the vicinity of a selected site would probably render that form most eligible which should be strictly on the vertical-wall system, the masonry rising directly from the bottom. On the other hand, there may be cases with an abundance of stone in the immediate vicinity, well adapted for the formation of a rough rubble mound, but not suitable for masonry purposes.

At present there is an experiment being made at Portland, to which we think it necessary to refer. In the case of the outer or detached breakwater now in course of execution there, it has been found that the form of the rough rubble mound, after being exposed for a time and adjusted by the action of heavy seas, arrives at a state of rest, and the result of the experience of the last few years has been so satisfactory, that the construction of all masonry work upon the rubble substructure has been postponed, in the hope that any further disturbance of the materials will be so slight as to be practically of no moment, thus rendering a superstructure of masonry unnecessary, so far as its use as a simple breakwater is concerned; but upon the inner breakwater, which is connected with the shore, and will be used for the purpose of coaling steamers, the case is different, and accordingly a superstructure of masonry has been erected upon the rubble mound, as will be seen in the plate. The fixed character of the mound as it now stands in the outer breakwater, is owing to the supply of rough materials being maintained until the sea has formed the surface to the slopes indicated. Attention is also given to the admixture of the due proportion of several sizes of stone, in order to leave as little vacant space as possible. As a result arising from the rough character of the surface, the waves striking upon the seaward slope are broken up in detail, and there is consequently no body of water to recoil and disturb the stone when receding.

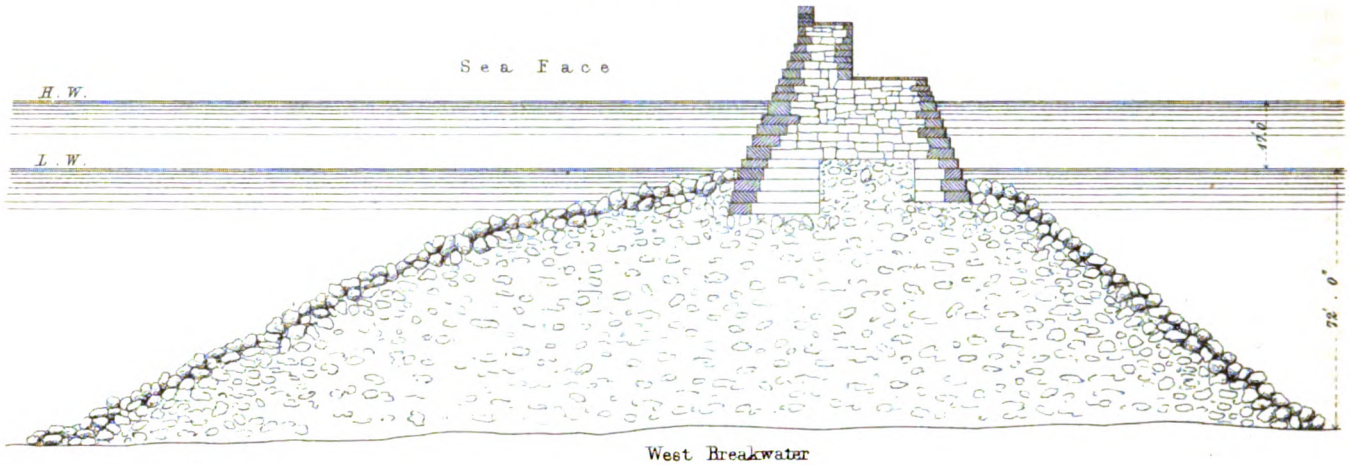
At the time when the vertical-wall was proposed for adoption, it was stated that any departure from the system previously resorted to would be 'a retrograde step in the path of science,' and it may possibly now be remarked that the formation of a breakwater by means of a simple mound of rubble, without masonry of any kind, is an unscientific mode of proceeding; but we conceive however that course of action to be preferable, and truly in the path of science, which effectually takes advantage of natural laws to accomplish the object in view, provided it be not attended with countervailing disadvantages. Should further experience confirm the success of the trial, it must necessarily have an important bearing upon the economy of works at those sites where the materials may be suitable and abundant.

Digitized by Google

Digitized by Google

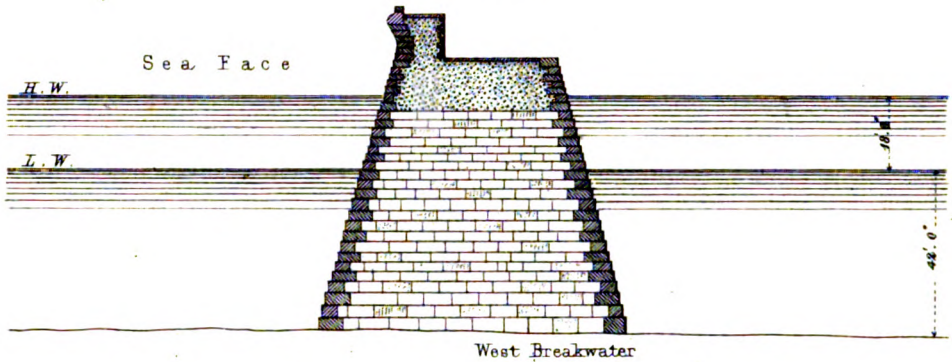
BREAKWATERS.

ALDERNEY.



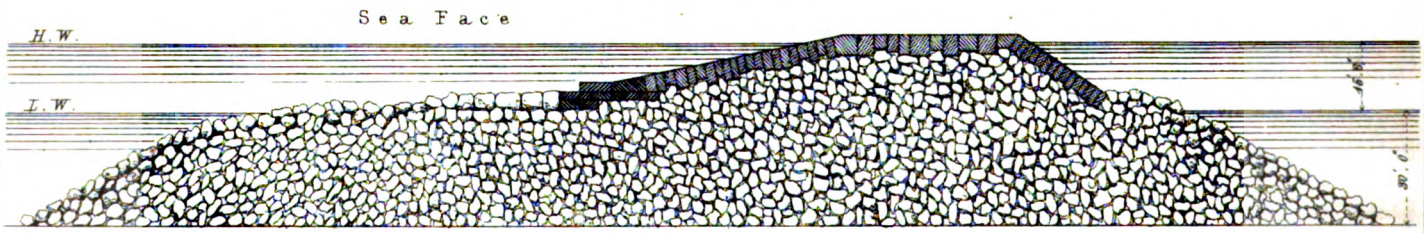
West Breakwater

DOVER.

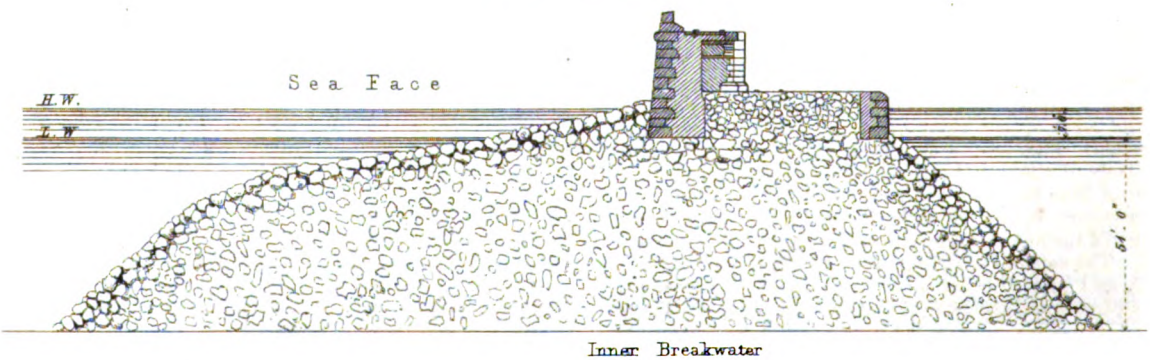


West Breakwater

PLYMOUTH.



PORTLAND.



Inner Breakwater

SCALE OF 0 10 20 30 40 50 100 150 200 FEET

July 1859

J.R.Jobbins

Digitized by Google

Modes of construction.—Proceeding to the different modes of construction in the order laid down, we have first the Plymouth breakwater. In this case the stone was taken in its rough state, and transported from the quarries to the site of the work by means of vessels built specially for the purpose. When the stone was deposited on the intended line of work, and the sea allowed to dispose of the materials, the result was the form indicated by the cross-section in the Plate, the only artificial aid to the determination of this particular form being the deposition of a considerable mass of stone, in the form of a benching or foreshore about 60 feet in breadth, which was added on the seaward side after the work had made considerable progress. The top, which is about 3 feet above the level of high water of spring tides, and the slopes both on the sea and harbour sides, were then pitched or paved with blocks of squared stone many tons in weight, and set on edge. In consequence of the scouring action arising from the recoil of the waves during heavy gales, the blocks immediately at the foot of the sea slope have been frequently undermined, and damage has arisen; to obviate this evil large squared blocks of granite set on horizontal beds, and dovetailed horizontally and vertically, are being introduced at the bottom of the slope, as indicated by dark shading on the section.

The new pier or breakwater at Dover is formed by an outer and inner wall built of ashlar masonry, with a course of granite on the face, and blocks of concrete made with Portland cement and shingle in the body or core of the work up to the level of high water, above which the hearting is filled in with liquid concrete. The masonry commences directly from the surface of the chalk which forms the bottom of the bay, the blocks being set below the water by means of diving apparatus. The sea and harbour faces of these walls are not strictly vertical, but have an inclination or batter in steps, of about three inches to the foot. On the sea side there is a parapet 15 feet above the level of high water, surmounted by a blocking course on the outside; towards the harbour there is a quay or roadway, about 30 feet wide and 10 feet above high water of ordinary spring tides. The whole of the operations necessary for setting the masonry are carried on from timber staging.

The breakwater at Alderney is formed by means of a bank of rubble stone, which is conveyed by means of a railway from the quarries about three miles distant, then loaded in hopper barges and discharged on the line of work until it reaches within 12 feet of low water; upon this bank a timber staging is erected, from which the masonry is set. The courses below low water on the sea face are of granite, and the backing of the walls of concrete blocks made with shingle and Portland cement, as in the case of Dover. The wall on the harbour face is composed entirely of concrete blocks below low water, and above that level both the sea and harbour walls are formed of large flat rubble masonry; the stone is quarried in the island, and the portion between high and low water is set in cement. At 6 feet above high water of spring tides, there is a platform or roadway of 25 feet in width. The seaward wall is carried 14 feet higher than this roadway, thus forming a protection against the sea in heavy gales; and this is surmounted by a parapet 4 feet in height. At the foot of the sea wall, rubble stone is deposited up to the level of low water of ordinary spring tides. All the operations requisite for completing that portion of the work above the level of 12 feet below low water, are performed from the timber staging before referred to.

The inner breakwater at Portland is formed by a rubble mound, composed of stone of all sizes, from 6 and 8 tons down to small chippings; and this mound is carried up to a few feet above the level of high water of spring tides. When it has been washed by heavy seas, a trench is excavated within the body of the mound to the level of low water of spring tides, and a wall of masonry erected. The face course is formed by large ashlar blocks, the body of the wall being of heavy rubble work set in mortar made of blue lias lime and pozzuolana. The ashlar face courses up to about 6 feet above high water are of granite, all the remainder of the stone employed being raised in the quarries in Portland. The sea wall is strengthened by counterforts placed 20 feet apart, and an arch being turned between each, a platform is obtained 15 feet wide, exclusive of footway and parapet. There will be a line of railway both on the upper and lower platforms, for the purpose of conveying coals and general stores to vessels of the navy that may lie alongside the jetties, one of which is now nearly completed. The whole of the operations at Portland are carried on from a timber staging, the rubble stone being conveyed in waggons drawn by locomotive engines, a mode introduced by the late Mr. Rendel, C.E., and in every way attended with success. It should be observed however that, guided by results obtained elsewhere, it was decided when the work was commenced to keep all the horizontal timbers of the staging not less than 12 feet above high water of the highest tides, and experience has shown that this is necessary to ensure safety.

NOTES AS TO THE CONSTRUCTION OF BREAKWATERS FOR HARBOURS OF REFUGE.*

By D. and T. Stevenson, Edinburgh.

The advocates of plumb walls for the seaward faces of breakwaters base their views on the assumption that all deep-water waves are pure waves of oscillation only, and have no percussive force. There is however no proof that purely oscillatory waves if opposed by a *continuous upright wall* exert only the hydrostatic pressure due to their height. Nor is it determined by actual observation that oscillatory waves, if reflected from the face of such a wall, may not cause succeeding waves in approaching the wall to break, at least partially, and thus to become to some extent waves of translation.

But even if it be admitted that purely oscillatory waves would not be found to exert percussive force, and that such waves would not be reflected so as to cause succeeding undulations to become waves of translation, the important question still remains to be answered—Are all deep-water waves really simple waves of oscillation?

During a perfect calm pure oscillatory waves no doubt traverse the ocean, but a gale of wind or a rapid tideway produces an entire change in their condition. All waves such as we are speaking of, owe their existence solely to the wind. Its action on the surface of the sea is such as to cause the water to rise in the form of a wave, the height of which depends on the amount of force exerted by the wind, and the time during which that force continues to act. When the wind ceases the waves are influenced only by the action of gravity, and become purely oscillatory waves; but so long as they are urged on by a heavy gale their symmetrical shape as undulatory waves, it is believed, cannot be maintained; and being impelled by the continued action of the wind on their windward side, the equilibrium is ultimately destroyed, and the upper part of the wave, urged on by this extraneous force, tumbles over and becomes a wave of translation. Were it possible to oppose a sloping face or a plumb wall to such a wave in the middle of the ocean we should unquestionably have the phenomena due to a wave breaking on such an obstruction. When waves break in the ocean, however, they are unobstructed by any fixed object, and are spent in plunging into the medium of which they themselves are composed, and are thus as it were swallowed up and lost to external observation. But still, even in the middle of the Atlantic the breaking wave is an invariable accompaniment of a storm, and from the great distance at which such breaking waves may be descried, and from their formidable appearance when breaking near a ship's course, and also from the actual damage which they have been known to do to the *windward* bulwarks of vessels, we are led irresistibly to the conclusion that the phenomenon is something more than mere superficial disturbance, and is in fact, as has been stated, a truly breaking wave. Again, in great storms it is admitted that waves break long before they reach the shore, in consequence, (as explained by the advocates of the purely oscillatory character of oceanic waves) of the depth of water being too small to admit of their propagation, and it has been variously stated by different authorities that from this cause waves break in water of from 5 to 7 fathoms in depth.

Harbour works are not likely in almost any case to extend beyond the 6 or 7 fathoms line, and from what has been said as to the effect of wind and shoal water in causing the sea to break, the three following inferences seem clearly to follow:—

1. That all harbour works, whatever be their form, or in whatever depth of water they may be placed, will be exposed during storms to those partial waves of translation which are due to the action of the wind.

2. That all such parts of these works as are in water of less depth than from 5 to 7 fathoms will be further exposed

* Originally addressed by request to the Royal Commissioners on Harbours of Refuge, and now communicated to this Journal by the authors.

Digitized by Google

to waves of translation due to the shallowness of the water.

3. That it is incorrect to assume that the works of harbours of refuge are never to be exposed to any greater force than that which is due to the pressure of purely oscillatory waves.

Assuming then that our sea works, whatever be the depth of water in which they are placed or the form or profile which they present to the sea, will necessarily be assailed by some kind of breaking wave, though we do not pretend to define to what order of waves they belong; the next question to be determined is the construction of breakwater which is best fitted to resist their action.

Perhaps we may assume it to be generally admitted that a *breaking* wave impinging on an upright wall rises higher and gives the resisting structure a greater shock than would result from the same wave impinging on a sloping talus wall. At North Unst, in Shetland, the sea rises on a nearly perpendicular face upwards of 200 feet, and at Barrahead, in the Hebrides, the waves rise still higher. Every one, indeed, who has watched the effect produced when a breaking wave impinges on sloping and on plumb walls which closely adjoin each other (which we have had many opportunities of doing) must have satisfied himself that while the sea rises and falls gently on the sloping surface, it strikes the nearly perpendicular face with great force, producing a loud report and raising the spray 30, 40, or 50 feet into the air.

In considering this result and others that have been noted, we are led to the conclusion that in designing works to withstand the sea the great aim of the engineer should be to resist or oppose the progress of the wave as little as possible. It is practicable to *direct*, but certainly not altogether to *check* or *control* the action of the sea by artificial works. This is well illustrated in practice by the difficulty which invariably occurs in forming a junction between a sea-wall and a projecting rock. If the projection arrests the progress of the wave suddenly the artificial work at the point of junction is certain to be very severely tried. For the same reason, in situations where the sea is confined between elevated rocks, it is believed to be in some cases all but impossible with ordinary materials to construct artificial works of sufficient strength to withstand its fury. Hence it is believed that horizontal projections in works which are intended to withstand the sea are not good in principle, as they tend to shake and try the masonry. It is safer engineering to allow the sea to expend itself in rising up perpendicularly in the form of spray or in flowing over the work in a sheet of water, than to attempt abruptly to resist its action.

These considerations seem to lead clearly to the inference that the most suitable form for the sea-face of a breakwater is that of a sloping talus wall, and, were it not for the great difficulty of founding and afterwards preserving in security the foundation of a sloping wall, and the great mass of material required in the construction of a breakwater designed on that principle, it would be a matter of prudence to adopt it. The disadvantages we have just noticed however are, we think, so great as to warrant the engineer to abandon that principle of construction for deep-water harbours of refuge. The plumb wall on the other hand, if brought up from the bottom, secures a comparatively small consumption of material, but the expense and the difficulty of founding such a wall in deep water in the open sea is a most serious drawback; and even if such a wall may, after its completion, possess all the advantages claimed for it by its supporters, still it must be remembered that these advantages cannot, as first suggested by Mr. T. Stevenson, be available so long as it is *in progress of construction*. All engineers will agree that the greatest risk which seaworks undergo occurs during their construction. If the process of building has been completed there is very little fear of the work in its finished state being destroyed. But during the critical period when the work is in course of execution both the facework and hearting are left open and unfinished, and the adoption of a plumb wall can be attended with no benefit whatever based on the assumption either that deep-water waves are oscillatory or that they will not become waves of translation if opposed by a plumb face. For it is well known as a matter of fact that the seaward end of such a wall while in progress is not, and never can be plumb, but consists of a succession of steps formed by the unfinished courses of masonry, which must necessarily be left projecting as the work proceeds. On this sloping end the sea during the whole progress of the work makes a clear breach, and the wall, even if executed on the plumb principle, is, along with the interior or backing, exposed to *breaking waves* during the whole period of the execution.

Holding these views we have been led, after much consideration, to recommend the form of structure shown in the sections of the proposed breakwater which have been submitted to the commissioners, a form which we originally suggested in 1856, when designing the Refuge Harbour which was at that time proposed to be erected in Wick Bay by the British Fishery Society. Fig. 1 is a cross section, and Fig. 2 is an elevation of the sea face of the breakwater.

Fig. 1.

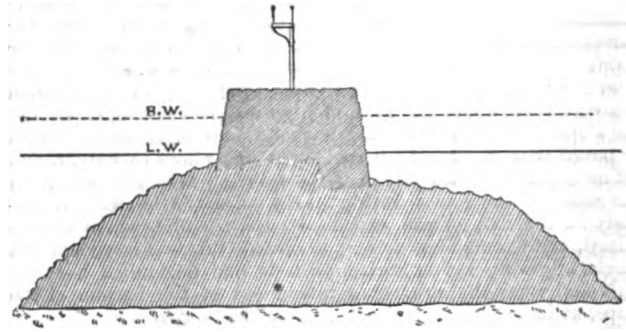
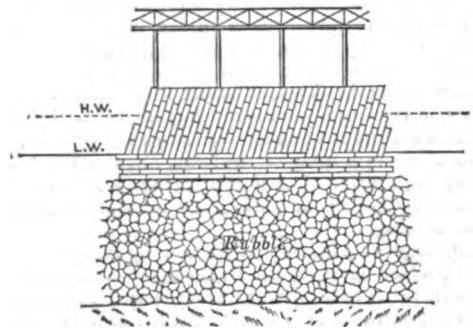


Fig. 2.



The profile of this breakwater, which may be regarded as a combination of flat slops and nearly plumb faces, possesses the following advantages, which our experience leads us to believe are worthy of consideration:—

1st. The underpart of the breakwater is formed of rubble which, when dropped into the sea from a staging, as has been so successfully used at Holyhead, by Mr. Rendel, adapts itself to the varying form of the bottom, and, when it consists of sand or other soft matters, the rubble sinks into it and forms a sufficiently wide spreading and safe foundation on which to erect upper works.

2nd. This rubble work is not carried above the height at which the larger sizes of stones are found to be moved by the action of the sea, a height which varies with the exposure from the low-water level to 12 or 15 feet below it.

3rd. The saving in cost in bringing up the lower part of the work by depositing rubble is, in most cases, beyond dispute. The uncertainty of founding an ashlar wall on a soft or uneven bottom in the open sea at a depth of 5 or 6 fathoms is, as has been already stated, a great objection to the system of bringing up the walls plumb from the foundation; while any settlement in the lower courses is likely to occasion the total destruction of the upper works. When rubble suitable for such a work can be obtained at a convenient distance, we therefore think that there cannot be any doubt as to the propriety of forming the deep-water part of the work with that material.

4th. The use of unprotected rubble however cannot, except in some cases, be advantageously adopted above low-water mark; while in other situations it cannot even be carried so high, for the action of the sea scatters the rubble, especially above the level of low-water. This difficulty has been found to be very inconvenient at Kingstown, and other works of similar construction, where the rubble was carried out with a high face and tipped over in the same way as practised in forming a railway embankment. This mode of construction exposes a large mass of stones above low-water to the action of the waves, which scatters them and greatly increases the mass of material required to form the breakwater.

Digitized by Google

5th. In order to obviate this difficulty the construction we recommend for the upper work is a rough but very strong wall, founded on the rubble, and composed mainly of stones set on edge. For that system of building we believe the profile shown on the section will be found to be best suited, but we are not prepared to say that more batter may not advantageously be given to the walls and a certain amount of convexity to the top. As the cubic contents of this superstructure bear but a small proportion to the mass of the breakwater itself, great facilities are presented for selecting suitable materials for its construction whilst quarrying the rubble for the under-water work.

6th. The vulnerable part of any sea-wall founded on rubble is the foundation, because the rubble stones are liable to be washed from the toe or foot of the wall. If the wall be surmounted by a high parapet this action of the sea on the lower portions of the work is greatly increased, whether the face of the wall be plumb or slightly inclined; and in order to modify the effect of that action we propose to dispense with a parapet on the proposed breakwater, and to allow the sea to pass freely over it. In this way we believe that the foundation of the outer or sea wall will be much less severely tried, and that the chances of its security will be greatly increased. As a proof of this particular action of the sea on a pier without a parapet, we would cite the results of some careful observations made by us at a harbour where a breach had been made in the parapet of the sea-wall, whose direction was parallel to that of the wave, and which was moreover exposed to a very heavy sea. On a wave approaching the pier, it struck the part which had not been damaged, and rose to the height of 30, 40, and even 50 feet above the parapet (which was 22 feet above high water); while that section of the wave which faced or was opposite to the breach, flowing freely over the pier, fell into the harbour without producing almost any commotion in the basin. While this comparatively peaceful flow of the water over the pier was going on, the other part of the structure with the high parapet was exposed to an intense force, and the foundation was of course subjected to a correspondingly great reaction. That portion of the facework opposite to the breach which was not destroyed had a curved batter increasing towards the foundation, where it was about 1 to 1. This work was superseded by a new wall with a straight batter of 2 inches to the foot, or nearly plumb, and the same action which we have described was observed on the new work while it was in progress,—the sea rising in masses above the finished parapet, and flowing over the unfinished or low part of the nearly plumb wall.

7th. The observations made at the place in question, and others of a similar kind which we have made elsewhere, lead us to the conclusion that while high parapets in very exposed places certainly do not render the roadway of the pier safe in heavy storms (when communication is often most needed), they tend greatly to aggravate the shock of the sea on the face-work and foundations, and increase the recoil of the wave, the work is further endangered by the falling of heavy masses of water on the roadway from heights varying, according to our own observation, from 20 to 70 feet. It therefore seems to us to be very questionable in how far it is consistent with sound engineering to erect a high parapet at a heavy cost on a breakwater which is not intended to serve as a commercial pier, but is designed only to protect vessels lying under its lee.

8th. To secure access along breakwaters without parapets such as we recommend, we propose to have a raised gangway supported on some of the staging-piles which will be left in their places for that purpose. The solid water, as in the case of the breached pier already alluded to, will pass comparatively gently *over* the surface of the breakwater and *under* the platform, which will only be exposed to spray caused by the striking of the waves against the comparatively low plumb face of the pier, chiefly at or about the period of low-water. We believe that there will not, excepting in very peculiar circumstances, be any danger in passing along such a stage; and it is confidently anticipated that a passage may be comfortably effected along a stage so constructed in states of the sea when the roadway of a pier would be altogether impassable even if it were protected by a high parapet.

9th. No objection can be raised as to the stability of such a staging. Abundant proofs can be given where isolated piling, in consequence of the sea getting free access round it, has stood perfectly secure, when large stones built into a wall alongside of it have been carried away, simply because the progress of the wave was opposed by the continuous wall.

The peculiarities of the form of breakwater which we have recommended may be stated shortly as follows:—

1. Advantage is taken of the non-moving power of the sea at low levels to employ for the under-water work rubble, which is a comparatively cheap material.
2. This arrangement secures a perfect adaptation of the foundation of the structure to the bottom, however soft or uneven.
3. On the rubble so deposited a superstructure is raised, composed of materials arranged on edge, and protected where necessary by such a system of iron strapping as shall eminently qualify it for withstanding the sea during its erection.
4. The stability of the work is further provided for by having no parapet, and thus the force of the waves on the sea face, and especially on the foundations, will be reduced, while the fall of masses of water from a great height on the pitching is prevented.
5. Communication is obtained by an elevated gangway supported on piles and raised above the passing seas.
6. The proportion of the expensive ashlar work forming the superstructure is very small as compared with the whole mass of material.
7. For breakwaters intended merely to shelter vessels, no parapet is required; and in situations where such breakwaters are likely to be erected, no parapet could during bad weather render the piers suitable either as berthage for vessels to lie alongside, or as roadways for safe communication.
8. The form of breakwater proposed therefore combines efficiency with economy.

THE LATE CHEVALIER MONTFERRAND.

Monsieur de Montferrand is among the remarkable architects of the present century—remarkable for the position he occupied in one of the leading European capitals, for the important monuments he erected, and for his great personal success. He was a Frenchman by birth, having been born at Chaillot on the 24th January, 1786, and was a scholar in the fertile classes of Percier and Fontaine, at Paris, from which proceeded so many men eminent in the art; and whose taste, as teachers, had so great an influence upon the monuments of Continental Europe of the first quarter of the present century. It is difficult to state precisely the causes which led to the predominence which Percier and Fontaine exercised upon the rising youth of the French school of architecture. Much arose from their releasing students from the thraldom of the vicious taste of the Louis XV. period: and much was due to the personal qualities of the former of these distinguished men, whose mastery of the pencil and enlarged views of Classic art no doubt gave him great weight. But the rigid laws of the Classic canons had to yield after his decease to those ideas of individual freedom of thought which have since enlarged the sphere in which the imagination of the rising generation has allowed itself to wander. De Montferrand appears to have been engaged upon the works of the edifice which subsequently became the Eglise de la Madeleine, and which from the time of Louis XV. had undergone various transformations in its conception and decoration. In the German wars, which concluded the career of Napoleon I. we find him in the army, which he quitted at the restoration. For such a spirit Bourbon France offered no chance of success, and after studying in Rome for a short time, where Dupaty, Milhomme, Calamar, Granet, Chauvin, Nepveu and others were his comrades, he sought in Russia a field of enterprise for his talents, where from the paucity of able architects he soon found employment, and constructed the Palace of the Prince Labanoff. In 1817 his design was successful in a competition for the new church of St. Isaac, which was intended to supersede the older fabric, and to vie, as the Cathedral of the Russian Empire, with the others of Christian Europe; and which was not completed till forty years afterwards. With unlimited funds at his disposal, the choice of the materials left to his discretion, and with no restrictions in any respect, the church of St. Isaac, though gigantic in its proportions and profuse in its decoration, falls short of its object and does not fill the eye nor satisfy the taste. In 1829 he was charged by the Emperor Nicholas to erect a column commemorative of his brother Alexander, without any reserve as to cost. De Montferrand wisely determined that this project should bear comparison with the monuments of ancient

Digitized by Google

art in the choice of the material and the colossal scale of its monolith. The shaft consists of a single block of Finnish granite from Pytterlaxen, 11 ft. 6 in. diameter and 84 ft. high, and is of Roman Doric proportions with appropriate pedestal, base and capital, surmounted by a pedestal and a bronze statue of Religion. It is necessary to read his volume on this work, which shows the difficulties he had to overcome, and the rude workmen he had to educate in order to carry out his noble idea. This colossal columnar memorial is one of the most striking features of the Northern Metropolis of Russia. His last public work was the pedestal for the equestrian statue of the late Emperor Nicholas, consisting of enormous blocks of porphyry and bronze sculptures, surmounted by the colossal figure of the Emperor on his war charger, and which was intended to excel in scale and execution that of Frederick the Great at Berlin. But here was wanting the genius of a Rauch to give the impress of that elevation of sentiment and originality of conception and treatment, which render the monument of the Prussian king the finest example of modern monumental sculpture. This was his favourite, as well as the last work of his artistic career, with which Montferrand closed a practice of about forty years in St. Petersburgh.

He deceased in June 1858. The Chevalier had a great love for art, and collected a museum, which with patriotic zeal he wished to see placed in one of the towns of his native country, like the Wicar collection at Lille. This is a noble instance of the public spirit of an artist, anxious to endow the soil of his birth with a memento that should serve to promote the love and study of a pursuit, in which he had himself been distinguished. He published two noble volumes, illustrating the Cathedral of St. Isaac and the Alexandrine Column.

HOUSES IN RELATION TO HEALTH.*

By Robert Druitt.

The speaker having alluded to the sickness, bereavement, and ruinous expense which sometimes ensue from the wrong choice of houses by private individuals, and to the disorders liable to be diffused amongst all classes from the unhealthy dwellings of the poor, proceeded to consider the subject of houses and their influence on health under three heads. Under the first he treated of deficiencies of air, light, warmth, and dryness, and of the maladies of degeneration to which they give rise, of which consumption and scrofula are types; under the second he spoke of the common typhoid fever of this country, and of choleraic disorders, and of their origin in defective house-drainage; and under the third he discussed the conditions which give intensity and power of propagation to certain diseases, such as scarlatina and diptherite.

Amongst the details noticed under the first head, he observed that the ground on which a house is built should have the qualities of porosity and firmness; porosity is required in order that all water charged with organic debris which happens to penetrate it, may pass onwards and undergo that rapid oxidation which is so happily effected by the London gravel. Wherever the soil is deficient in this quality, or where beds of gravel or sand come in contact with beds of clay, a thorough subsoil drainage is as essential for the health of man, as it is for the growth of sweet herbage. Spots can be pointed out in which the subsoil is swampy, and where fever has prevailed in consequence. Moreover, the land on which houses are being built around London is sometimes raised artificially by what is called made-earth; that is to say, on a low wet spot quite undrained are heaped all sorts of rubbish, road scrapings, mud, and refuse, mixed with organic debris; and over this the houses are built. Besides, the excavation of sweet wholesome gravel, and the filling in the vacuity with rubbish, has long been prevalent at the west of London, and was much to be condemned; and an instance was quoted of a house, whose rental was 400*l.* per annum, built over a laystall of the last century, that is a pit where every kind of impurity was deposited, and now filled with black mould mixed with sheep bones. This earth, when dried and analysed, yielded 10 per cent. of organic matter, and was as unwholesome to build on as an old churchyard.

Want of firmness might be remedied by a solid floor of concrete, after the Roman manner, which would enable houses to be built with less chance of settlements and cracks, which are causes of unhealthiness, not merely by allowing cold and damp to enter, but by permitting currents of fœtid air to come from unknown and distant sources. Thin walls, too, render a house not only extremely cold, but unwarmable in winter.

Passing over the grouping and position of houses, and the width of streets, which ought to be regulated by the height of the sun in winter, we come to the internal arrangements and air supply. The last may be provided by some special ventilating apparatus, or may be left to take care of itself: but even if left to itself, it will be prudent to see that the basement doors, and other chief apertures, are not near any source of contamination; moreover, great caution should be exercised in roofing in yards and areas with glass, as is often done, because the glass may cover over some sources of effluvia, and bring them into the house. This has been the cause of fever.

The supply of air to the apartments should be large, diffused, and not in perceptible draughts, and warmed, and should be so contrived as not to attract attention: otherwise persons who are afraid of pure air, especially servants and the poor, will speedily close up the apertures. The plan suggested by the Commissioners on Warming and Ventilation was exhibited, and described as fulfilling most of these conditions—inasmuch as the air is warmed by the heat otherwise wasted by the chimney, and is introduced in ascending currents; and care is taken that there is a channel of escape separate from the chimney, and that the upper part of the apartments should be the coolest. Any plan for bringing currents of cold air to the level of the feet, or of the bed, is to be condemned. Nothing can be a better evidence of the carelessness of our present system of air supply to houses, than the fact that much of it comes down the chimneys when there is no fire, bringing with it abundance of soot, and many, possibly unwholesome, products of imperfect combustion of organic matter. A free supply of pure air is the *sine qua non* to persons who lead in-door lives.

Further researches on the composition of house air are to be desired. It is evident that the amount of carbonic acid represents that of the most volatile, and probably that of the most innoxious product of the presence of living beings, and consequently the *minimum* of atmospheric impurity. The speaker had made several determinations which showed how rapidly the quantity fluctuated according to the amount of ventilation and the state of the wind. For example, in a small room in May's-buildings, Brick-street, inhabited by two adults and three children:—

	Volumes of Carbonic Acid in 10,000 vols. of air.
April 20th. Noon; family dining	13·74
„ 21st. „ „ „	9·19
„ 24th. Room empty, door open	3·34
„ 20th. All night	15·97
„ 21st. „	15·10
„ 22nd. „	12·27
In the Infant school-room, Curzon schools, Mayfair, room crowded, with a window open at each end	9·46

In a bed-room, unoccupied, but with the doors and windows closed all day, the quantity fluctuated between 5 and 7 volumes per 10,000.

The list of maladies arising from cold, damp, airless, and sunless dwellings, is a long one, and is identical with the maladies caused by hunger, depraved nutrition, solitude, and grief; moreover, the effects of dark, monotonous and decayed dwellings upon the mind must not be overlooked, inasmuch as they produce a direct temptation to indulge in spirituous liquors.

Under the second head the speaker alluded to the great number of modes in which a house may receive poisonous vapours from sewers. If the house drainage has not been revised during the last ten years, there may probably be every variety of imperfect and dilapidated drainage; wells that once supplied a family with water may have been converted into dead wells and receptacles of filth; and even when a house possesses a perfect drainage system of its own, it may be invaded by its neighbours; or the remains of old drainage systems may have been left by the carelessness or ignorance of workmen. Every pipe too, of whatever sort, may be a means of bringing foul air from sewers; every such apparatus should therefore be examined from time to time, and be regulated with philosophical precision. The possibilities were described of the entrance of air from the public sewers into houses, either from stagnation and decomposition, or through the wind which at certain times penetrates the great sewers from the river; then, wherever a sewer ends abruptly, the gases are sure to be driven out of it, through the apertures in the streets made for ventilating purposes.

* From a paper read at the Royal Institution.

Digitized by Google

The effects of back house drainage, and of sewer poison, are found in the prevalence of typhoid fever and choleraic maladies. The great fevers at Clapham, Croydon, Westminster, and Windsor, were all of this sort, and traceable to this cause; and instances were given of illness, year after year, visiting a family, and robbing it of one or more lives; and when too late, the discovery made that an ancient, unknown, and decayed sewer ran under the premises. Many such sewers exist underground, not noticed in any map, and unknown to the present generation of officials; serving only as reservoirs of foul gases, which find vent through most unexpected channels.

It is in vain for the physician to discuss remedies whilst the patient is still breathing the vapours which caused the disease.

Lastly, the property which the diseases have of lurking in certain quarters, and then breaking out with virulence, and acquiring a self-propagating force, was ascribed to impurity in general, and to defective drainage in particular. Scarlet fever, especially, was asserted by the speaker to be caused *ab initio*, as well as to receive power of extension from this source. Thirteen contagious maladies, at the least, can be produced at will; and the speaker believed that in time epidemic diseases would be found subject to human control; and that the surest mode of protecting the dwellings of the rich was to cleanse and ventilate the dwellings of the poor.

Diagrams were exhibited, showing the mortality in several parts of the parish of St. George, Hanover-square, by which it appeared that, out of 20,000 inhabitants of first and second class streets there died at *home*, in the three years 1856, 1857, and 1858, 10·78 per thousand per annum; whilst, in third and fourth class streets, there died at *home* in those three years 20 per thousand per annum, exclusive of deaths in hospitals and workhouses. Taking the *mews* separately there died at *home* 15·36 per thousand per annum.

The mortality and population of several streets during these years were also exhibited in a diagram, which contrasted the low mortality of purely aristocratic and first-class business streets with that of the nest of low streets between Grosvenor-square and Oxford-street, where, owing to the crowded and unventilatable state of the houses, there is a mortality of 30 per thousand,—a mortality enhanced, of course, by the deaths of the children who are born but cannot be reared in such habitations.

ON THE ORDNANCE SURVEY.*

By Colonel James, R.E., F.R.S.

I am afraid you will find this a very dry subject, but I will endeavour to go rapidly over the various points, more with the view of giving a correct outline of the whole proceedings and history of the Survey, than of going into minute details, which would be more adapted for a book than a lecture.

The history of our Survey presents a most remarkable example of that gradual and slow development of just views which we often witness on other questions in this country; and as there has been so much discussion, and so many changes in the orders which have been issued from time to time respecting it, I have gladly availed myself of this opportunity to explain to the officers of the army and navy, and the public generally, the exact state of the question at the present moment.

The survey commenced under General Roy, R.E., in 1785; but the object then in view was simply the production of a military map on a 1-inch scale, and that survey, with considerable interruption, consequent upon the wars then going on, had extended in 1824 from the Land's End to the boundary of Yorkshire and Lancashire, including the whole of Wales. It was then decided that there should be a general valuation of Ireland, and that, as a necessary basis for that valuation, there should be a townland survey; Ireland being divided into smaller divisions of parishes than England, called townlands, which are generally co-extensive with private properties, averaging about 300 acres each.

The whole survey force was then sent to Ireland, and the survey of Great Britain was altogether suspended. We commenced first in the North of Ireland, I myself taking part in the survey. To obtain accurately the acreage of the townlands, which was at first supposed to be all that would be required, it was decided that the scale should be six inches to the mile; and then commenced that series of mistakes which has interfered with our proceedings up to the present day. For no sooner had we completed the survey of four counties, according to our instructions, than it was found that the skeleton plan, containing the mere boundary of the townlands and the principal roads and rivers, was altogether insufficient; and that every field and garden must be surveyed to enable the tenement valuation to be made. We had consequently again to proceed to the North and complete the survey, and we have hardly completed it yet, having to put in every single field through the northern counties of Ireland. Our parties are now finishing it—they are in Armagh, and have nearly completed that county; and, when that is finished, I trust it will close the six-inch survey of Ireland. But the mistake and its consequences do not end there. Under the newly-constituted court, which was called the Encumbered Estates Court, and which is now called the Landed Estates Court, a vast amount of property is being constantly sold; and for the purpose of sale they require accurate plans of the property. When you bear in mind that on the six-inch scale sixteen acres occupy one square inch only, you will understand how inadequately represented upon that scale were the small sub-divisions of property. By a curious coincidence just as a royal commission on the survey had recommended the 25-inch scale for the survey of Great Britain, the judges of the Landed Estates Court in Ireland made an application, which has received the sanction of the Treasury, for the introduction of the 25-inch scale for Ireland, for the plans of all estates sold under the Landed Estates Court.

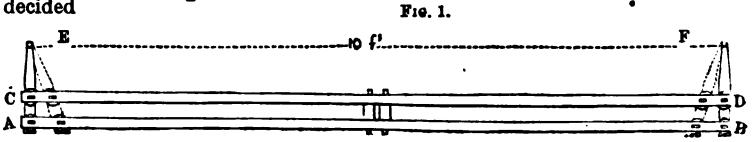
The survey of Ireland was completed on the six-inch scale; and, although it is to be regretted that it was not made in the first instance on a much larger scale, still it was found to be of such immense benefit as compared with the one-inch, that, when we resumed the survey of Great Britain in the North of England and South of Scotland, we were ordered to proceed upon the six-inch scale, as we had done in Ireland; and we completed the whole of Yorkshire and Lancashire, and several small counties on the South of Scotland on that scale. After we had completed Yorkshire and Lancashire, and several of the counties in Scotland, there commenced a discussion upon what was the proper scale for the plans, which, if it is quite closed, has only just been brought to a close; a royal commission, composed of many of the most distinguished men of the day, of which Lord Wrottesley, president of the Royal Society, was chairman, having unanimously recommended the adoption of the 25-inch scale as the national scale for our cadastral survey.

With these preliminary observations, I may proceed to describe the operations of the survey itself. The first requisite for a survey is, of course, a triangulation. When I say a survey, I speak of the survey of a great kingdom, not of a limited district. It is absolutely necessary that you should have an accurate triangulation. And, as a preliminary to obtaining an accurate triangulation, you must have accurate bases measured.

The bases that have been measured, and from which all the distances in that triangulation have been computed, were those on Salisbury Plain, at Lough Foyle in Ireland, Misterton Car in Nottinghamshire, Rhuddlan Marsh in the North of Wales, and Belhelvie in Aberdeenshire. The two first were measured with Colby's compensation bars, the others with steel chains 100 feet long (Fig. 1).

The compensation bars for the measurement of bases, which were designed by the late General Colby, are made in this way: a bar of brass, AB, is firmly connected to an iron bar, CD, at their centres; these are again connected at each end with two iron tongues, EA, FB, moveable on pivots. On the projecting portions at EF a fine dot is made on a piece of platinum, and it is so arranged that the distance from the dot to the centre of the pivot at C, shall be to the distance of the same dot to the centre of the pivot at A in the ratio of the expansion or contraction of the iron bar CD to the expansion or contraction of the brass bar AB. By this arrangement it will be seen that the distance between the dots at E and F remain at the uniform distance of 10 feet under every change of temperature.

Fig. 1.



These bars, in the actual measurement of the bases are laid perfectly horizontal by means of levels, and ranged in a perfectly

* From the 'Journal of the United Service Institution.'

Digitized by Google

straight line by means of sights upon them, and a directing telescope. To prevent any disturbance in the position of the first laid bar, when the next to be placed in its position is brought up, a double microscope (like an opera glass, the distance between the foci of which is exactly 6 inches) is placed on the end of the bar about to be laid in position; by this arrangement the first laid bars are never touched or disturbed, and the exact distance of 6 inches between the foci of the microscopes is preserved by compensation bars on the same principle as in the 10-foot bars.

Mr. Babbage and Sir John Herschel were present when upon Lough Foyle 500 feet of the base of seven miles were re-measured, and, testing it by the finest dot that was made with the point of a fine needle, it was found to be only the third of a dot in error; such was the extreme accuracy with which the operation was carried on.

It is of little consequence to obtain extreme accuracy in one portion of a work unless we obtain the same accuracy in every other portion. The horizontal angles of the triangulation, as well as the vertical angles and azimuthal bearings of the stations, were measured with theodolites 3 feet in diameter. These magnificent theodolites were made by the great Ramsden, who made one for the Royal Society, and one for the Master-general of the Ordnance. They were the first instruments which measured the spherical excess. All the angles in the triangulation having been observed, we had to encounter a most formidable question, namely, the correction of the observed angles, so as to render the triangulation perfectly consistent in itself; that is to say, so that the sum of the three angles in every triangle should be 180°, and the sum round every station 360°. To do that required a mass of calculation perfectly astounding; and, bold as the Russian engineers are in undertaking such questions, they were astonished when told that we had overcome the difficulty. The calculations which we had to make involved the solving of equations with thirty-six unknown quantities. For my part I have always considered *three* to be enough for a man with a moderate appetite for figures. The result of the triangulation has been this: By computing through the triangulation the length of one base from the other, and comparing the computed length with the measured distances, we found a difference of only 5 inches, the interval between Salisbury Plain and Lough Foyle being from 300 to 400 miles; and when we compared the computed with the measured length of the base in Aberdeenshire, there was a difference of not more than 3 inches. Therefore we have a perfect moral certainty that we have a triangulation (which is the essential basis of accuracy) determined with a perfection which was never before attained.

We now come to another important point. It is also absolutely necessary that we should accurately determine the figure and dimensions of the earth. Suppose you have a globe that is scored over with meridians and parallels. If a triangulation like a network is placed over it, you will understand that if the globe is either too large or too small, the points of the angles will not reach their required latitudes and longitudes; and therefore it is absolutely necessary in extensive surveys that we should get a perfect knowledge of the figure and dimensions of the earth. From our own series of triangles we computed the 10 degrees between the Shetlands and the Isle of Wight. If we multiply that by 36, we get the circumference of the globe, supposing the earth to be a perfect sphere. If it were a perfect sphere, every degree of latitude along a meridian would be of equal length. But we find, if we measure a degree of latitude in the South of England, and another near Edinburgh, and another in the Shetland Islands, the degree is 100 yards longer in Edinburgh than at Southampton, and 200 yards longer in the Shetlands; this is caused by the ellipticity of the earth, or the flattening at the poles. By the law of this increase we are able to determine the nature of the curve that is followed. The earth has an ellipticity of $\frac{1}{3}\frac{1}{0}\frac{1}{0}$, the polar diameter of the earth being 7899·5 miles, and the equatorial diameter being 7926·5. In this investigation we meet with a great difficulty, arising from the local attraction of the mountains which surround the stations at which the observations were taken. If for instance we take points north and south of Arthur's Seat, the attraction of the mountain would draw in the plumb-line towards it. This is made sensible by the levels attached to the instrument, the observed difference of latitude between the two stations being greater than is due to the distance along the meridian. Having eliminated the errors arising from this cause, we can determine the true figure of the earth, and we also obtain the data for determining the density of the earth, we can find the specific gravity of the mountain, and we know that the force of its attraction is in proportion to the mass, and in the inverse ratio of the square of the distance. So again the attraction of the earth itself is in proportion to its mass, and in the inverse ratio of the square of the radius. The ratio of these two attractions gives us the tangent of the angle of deflection in the plumb-line. If you suppose the mass of Arthur's Seat to be in the form of a small globe, whilst this large globe represents the earth, then the plumb-line, instead of going straight to the centre of the earth, will be drawn in the direction of the smaller globe. The result of this investigation is, that the attraction of the mountain was found to be about one-half only of what it would have been if it was of the same specific gravity as the earth, and that the specific gravity of the mountain being 2·75, the specific gravity or mean density of the earth is 5·316.

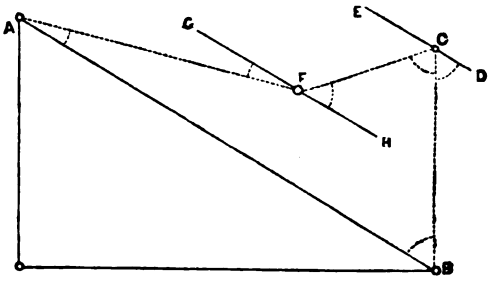
The larger triangulation, the sides of which are about 100 miles long, having been established, it was subdivided into smaller triangles of about 10 or 15 miles a side. The triangulation being completed, the "detailed survey" is commenced. In the organisation of the survey, the work is divided into several branches of which the triangulation which I have been describing forms the first; then follows the levelling, then the detailed survey, which I am about to refer to, then the preparation of the manuscript plans, and their final publication.

The whole survey force is 1500 men, in which four companies of the Royal Engineers are employed, forming a military nucleus which keeps all in order. This force is divided into sections for each branch of the work. In fact, we carry out the subdivision of labour to as full an extent as a manufacturer would in any other department of work, and we find great benefit to arise from this system. We find also that we can now advantageously, and at a great reduction of cost, introduce the system of piece-work, and we have recourse to it wherever the nature of the work admits of its adoption.

I speak in the presence of many gentlemen in the army and navy who are familiar with the ordinary modes of surveying, and to whom it is unnecessary to describe many things I am about to refer to. But, as the sailors say, to keep the convoy together we must regulate our rate of going by the slowest ship. The system of survey which we prefer, when practicable, is to give a man a triangle, or half-a-dozen triangles; he chains along the sides of each triangle, leaving pickets upon the lines as he proceeds in such positions as he thinks most convenient for taking the detail of the survey. Our reason for this is, that, having computed the distances from our base line, we know, to the fraction of an inch, what the length of each side is, and when we see the field-book brought in, we can tell whether the chaining of the three sides is accurate; and when we lay down the work on the plan, it will be seen that the cross lines will not fit into their places, unless they are also of the exact dimensions that they should be. Therefore, although we do not watch the proceedings of the surveyor, we have a most thorough check upon the quality as well as the quantity of his work.

This mode of surveying, viz., by chaining all the sides of the triangles, and a great number of internal lines, all connected with the sides, is the method we employ for the survey of the cultivated districts. The method we employ in the uncultivated districts, and which we must employ in the highlands, where it would be impossible to chain the sides of the triangles in the way I have described, is what is called traverse surveying.

FIG. 2.



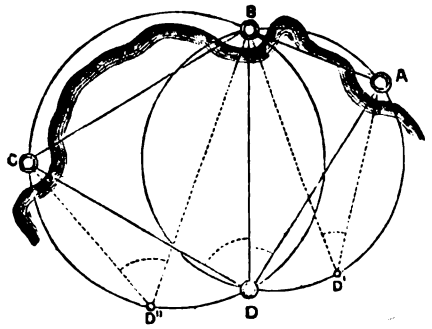
In surveying by traverses along the course of streams or roads, the theodolite is employed, and is first put up at one of the trigonometrical stations, and one of the sides of the triangle is taken as a meridian to work from (Fig. 2). The theodolite being placed in the direction of the meridian, BA, the bearing of the

Digitized by Google

first station, C, in the traverse is observed; then clamping the instrument, and chaining the line BC, set up the instrument again at C, with the plates clamped, and after clamping the underplate, release the upper and take the next forward angle to F, and so on through the whole traverse. By following this course, the bearings are always taken in reference to the direction of the line taken as the first meridian, because the first observed angle, ABC, is equal to the angle BCD, in which position the instrument has been placed at C, and the line ED is parallel to the line AB, from which we started. A similar system will be pursued at all the other stations, and when the traverse is closed at A, the angle BAF, if no mistake has been made, will be equal to the last observed angle AFG. The surveyor, therefore, has the means himself of knowing whether any error has been made in the angles during the course of the traverse.

Another mode of checking the work, and which enables us to say in what part of a traverse any error may have been made, is analogous to that adopted by sailors for fixing the position of any object near the coast. If he has three points, as ABC (Fig. 3),

FIG. 3.



determined on land, by taking the two angles which AB, BC subtend from a boat at D, he fixes his position, because there is only the point D where the two circumscribing circles intersect each other, from which they could have been observed. By taking the bearing of the trigonometrical station, the traverse surveyor fixes his station in like manner, and provides checks for his work as it proceeds.

I will next refer to the levels. The datum level assumed for the survey is that of mean tide. The tides, from high spring tides, continue to descend from day to day, till they come down to neap tide, again rising to spring tides; thus oscillating daily above and below the level of mean tide, which is the datum which we take, and all our levels are referred to that point. We take tidal observations at a great number of places all round the coast, and level along from one place to the other; we thus establish a series of levels, which again become points of reference for branch lines of levels in every direction. These again become the initial points from which contours can be set off, and the data obtained for making a model. An ordinary survey gives the plane surface of the ground only, but a contoured plan gives the data for a model, for it gives us the relief also.

Having described our methods of surveying, we must refer to the series of maps which the royal commissioners have recommended the government to adopt, and which, subject to the approval of parliament, we are ordered to go on with. For towns we have the large survey on the 1-500th scale, 500 feet being represented by 1 foot, or 42 feet by 1 inch.

For the parishes we have the 25-inch scale, which has been so much discussed. The 25-inch scale, which is equal to 1 square inch to an acre, is limited to the cultivated districts.*

For the uncultivated districts of the counties, the scale is 6 inches to the mile, the 25-inch plans of the cultivated districts being reduced to the 6-inch scale, so as to complete the counties on one uniform scale.

We again reduce the 6-inch plans to the 1-inch scale, to form the ordinary 1-inch map. Therefore, for certain portions of the country we have four scales. One great object in having this series of plans is to carry into effect that great measure which I believe to be most important for the agricultural and commercial interests of this country, namely, the facilitating the transfer of property. It is a question which, as I see by her Majesty's speech from the throne, is now at the commencement of this session to be taken up by the government.

I propose now to explain the manner in which we make the reductions of the plans by photography. Having that series of maps to make which I have described, it would be the most tedious and expensive thing imaginable, having the large plans upon the 25-inch scale, again to replot the 25-inch to form the 6-inch, and again to replot the 6-inch to the 1-inch, it being at the same time necessary that everything should be represented accurately. Seeing the enormous amount of labour involved by the whole process of reduction by the pentagraph, I directed my attention to the possibility of getting some other method; and, although I was at first discouraged by the photographers whom I consulted, I have now entirely succeeded by means of photography, and I may say with absolute accuracy; for a commission, of which Sir Roderick Murchison was chairman, has investigated the subject, and it is stated in the report that the greatest error is the 1-400th part of an inch; therefore, practically, we may consider the reduction as being absolutely correct. In making the deductions we use the ordinary collodion process. [*Several of the negatives were here exhibited, as well as a great number of positive impressions which were produced from them.*] In some instances several sheets have been joined together, and by the manner in which they join, it was evident that they were perfectly accurate, for if they were not so, the lines would not correspond. The success which we have achieved is, perhaps, more important as a question of time than of money; for the question was, how it was to be done at all, so as to get out the maps in any reasonable time; we now find that by the aid of photography we can strike off any number that may be required in a short time, and without the slightest difficulty. With regard to the saving of money, it saves us at the present moment, in wages merely, £1600 a year; and if the survey should be continued on the large scale, it would save £32,000, or not less than £40,000 in all.

The next thing was to introduce an expeditious mode of publishing the plans on a large scale. We first tried the system of lithography, but we eventually determined to try zincography. In the first place, the lithographic stones were enormously expensive; secondly, they were of tremendous weight, being several hundredweight to lift; and, what was still worse, when they had cost us £4 or £5 they frequently broke. We therefore determined to try zincography. In that attempt we have succeeded beyond all expectation; and I take no credit to myself for it, because I have been assisted by intelligent non-commissioned officers and others who carry out one's ideas in a manner most gratifying to me as superintendent.

Colonel James then proceeded: I should have explained before, that Corporal Neil has placed in the press a thin piece of tracing paper, which is laid over a plan and traced; all the figures referring to the fields, the acreage of which is given, are put in by mechanical means; not only is that done upon the tracing, but it is also done upon that which may be called the manuscript map. We have electrotyped the stamps, and the result is, that when the plans come in from parties stationed in different places, as at Perth, Newcastle, and Carlisle, for instance, you cannot tell one from the other.

After we have reduced the plans by photography, it is necessary to engrave the 6-inch sheets upon copper. It is so arranged that 16 of the reductions exactly cover the area of one of the sheets of the 6-inch survey, and therefore the reductions can be brought into their exact positions by placing the tracing from them over the marginal lines and trigonometrical stations as drawn upon the copper plate. The engraved work is cut into the plate; but we have introduced a great number of mechanical contrivances, as for making the letters, stamps for the trees, and ruling machines for the tints, and so on, which economises the labour of engraving; the result is, that we produce the plate from which the impressions are taken as you now see them, and at a very much diminished cost as compared to what it was formerly.

We now come to the sketching of the ground. We take the 6-inch impressions and put them into the hands of the field-parties to sketch the ground on. It was useless labour to make a reduced copy in manuscript when we had the engraved plan which we could give the men, and therefore we used the engraved impression. The ground having been sketched by the field-sketchers, as we term them, a drawing from the field sketch is next made on an outline impression on the 1-inch scale, and from that is engraved the 1-inch map which the public receive. You

* This is only approximate. (Ed. *C. E. J.*)

Digitized by Google

will observe the necessity of having the intermediate hill drawing, which requires a very first-rate artist to draw: this is a step which we should be very glad indeed to get rid of, and I have had a great number of experiments made with a view of effecting that object, and to get a copy by photography of the original sketches, straight down upon the plates, without the intervention of that drawing. I have here four experimental sheets intended to be sent to India, and I think we have in that trial sheet alone a pretty good proof that we shall succeed.

Any gentlemen who have examined the old sheets of the map of England must have observed how very much the plates have been worn in printing, and it has been a source to us of constant expense, and I may say of shame, to be continually repairing our plates and giving to the public very damaged and bad impressions. We now get rid of the whole of that difficulty. As soon as an original plate—of Edinburgh for example—is engraved, we put it in the electrotype battery (Smee's battery). Upon that original engraved plate we throw down by the battery a plate which is called the "matrix," and which is therefore in relief, and then again we throw down another plate upon the matrix which is the exact duplicate of the original plate; and so, for the mere expenditure of zinc and acid, we are enabled to produce any number of exact duplicates of the original plate. It is impossible to exaggerate the advantage which this has been to us. In the first place Sir Roderick Murchison, for example, requires a special map for his geological survey, and we take a plate for geology, leaving our original plate untouched. Again, we require indexes to the counties, examples of which are on the wall, and we take another plate for them. The indexes to the survey are by counties, whilst the engraving of the 1-inch map is by rectangular sheets. To make the indexes, we simply cut out those portions of several matrixes which would form one county. These several parts are then put together, and the electrotype copy taken, we are thus enabled to bring out the county map, which is a most beautiful engraving, and yet the hand of man has never touched it.

The accuracy with which these duplicates, made by the electrotype process, are made, and the manner in which the metal finds its way into every crevice of the engraving, is to me one of the most wonderful things I know of, and the more I contemplate it, the more astonished I am; if you take a microscope and compare the duplicate and the original, not the slightest difference can be discovered between the two. But still more astonishing is the process called acierizing, by which a steel surface is put on the copper duplicate, the object being to prevent the wearing away of the plate under the printing operation. We have examined the impressions from the acierized duplicates, and we cannot, even with the microscope, find any difference between them and the original. When we consider how extremely minute the particles or atoms of metal must be to produce such a result, it is quite wonderful.

RAISING SUNKEN VESSELS.

On the 18th ult. the first public trial was made of the hoisting capabilities of the large floating Derrick, moored in the Thames off Blackwall. The Derrick is erected upon a vast rhomboidal-shaped flat-bottomed iron vessel, 275 feet long and 90 broad, and which, although the plane superficies of the deck is nearly 18,000 feet, draws only four feet of water. On one side of the hull are 10 powerful cranes, each worked by a steam engine of 30-horse power, and the chains from which, after passing over certain iron pulleys, hang suspended in a row from a great boom. The united power of the engines working the cranes is 300-horses. In order to prevent the fabric, vast as it is, from capsizing during the raising of a vessel, it is provided with steam pumps, which fill a series of water-tight compartments, constructed for that purpose, and thus a counterbalancing power is obtained in precise proportion to the weight of the vessel raised. The operation of hoisting and pumping commenced about four o'clock, and in a quarter of an hour the vast mass of wood and iron composing the hull of the Foreingen had been raised 4 feet clear of the surface of the water. The Foreingen having been raised about 14 or 15 feet, the Water Sprite, an iron steamer, was brought underneath, and the machinery having been again set in motion, in three minutes the second vessel was raised above the surface of the water. Both vessels were then hoisted up, one above the other, and hung suspended during the rest of the day. The experiment, so far as it went, was successful. If the chains attached to the Derrick were once round the bottom of the vessel, all uncertainty as to the power of the machinery to raise her would be at an end. The real difficulty is how to weigh the sunken vessel so as to pass the chains under her bottom. That was a portion of the experiment which was not carried out on this occasion. The manner in which it is proposed to weigh the sunken vessel is to pass round it a chain and to sink on each side of it an iron diver, which is a pear-shaped mass of iron, weighing about a ton and a half. Through the ends of these iron divers the two ends of the chain on each side of the vessel are passed, and by lifting them and bringing them all together the iron divers are brought close to the vessel proposed to be raised, and a cradle is formed by which one end of the sunken vessel may be lifted, and the chains passed under.

ON THE ANCIENT ARCHITECTURE OF IRELAND.

Those specimens of Gothic or pointed architecture, of which Ireland possesses any remains, have, with very few exceptions, been derived from England; and from various causes, the best works of that kind which we do possess are greatly inferior to the ecclesiastical architecture of the latter country. Their history too in many instances must necessarily be obscure and uncertain. All the monastic archives and annals in these countries suffered great, too often, wanton spoliations. Besides these difficulties, it does not appear to have been the fashion of those remote times to have recorded much information connected with the foundation of those buildings, so that a chasm occurs in their history which conjecture will very imperfectly supply. As to the architects and builders actually employed in these erections, nothing certain is known.

From a recapitulation of what has been already advanced, it will appear that at the termination of the Roman empire in Britain, France, Germany, Italy, and even in the East, the Roman buildings were imitated by the natives of those respective countries, or by the rulers whose sway over them succeeded the Roman government. This imitation produced a general similarity of style in their architecture between nations very remote from each other. Every copyist varied a little from his model, and the imitations differed greatly from each other; but some general principles indicative of their source pervaded the entire, and might be traced through them all. In Britain these imitations were called Saxon; in France, Norman; in Italy, Lombardic or Gothic; and in Greece, Constantinople, and the eastern provinces, Byzantine.

With respect to Ireland, as she has never suffered under the tyranny and degradation of Roman subjugation, neither did she in those early times reap any of the advantages which the refinement of Roman arts and manners had diffused, more or less, among the other nations. Her architecture, therefore, until her conversion to Christianity was, if I may use the expression, in a state of nature, being little if anything improved by the casual intercourse of the Irish people with that once powerful and, at least comparatively, civilised empire.

If such be her state in the nineteenth century, why may we not, without much stretch of fancy, suppose a similar state of inequality of condition upwards of a thousand years ago? This supposition would at least solve the paradox which has puzzled many of our speculative philosophers, who cannot believe, and therefore treat as fabulous, those glowing pictures of ancient Irish splendour which Irish writers blend up with the simple manners of those early ages.

But to return from this digression. When new colonies introduced improved manners and new arts, domestic buildings would naturally improve; but their progress must necessarily have been slow and almost imperceptible. Until the introduction of Christianity, the national religion did not require any covered or inclosed building in which to celebrate its solemn rites. But when Druidism became exploded by the conversion of the people, the new proselytes would of course endeavour to imitate the churches which their instructors described as existing in other Christian countries. We may go beyond hypothesis in this matter, for the fact is we know that the first care of those pious apostles was to build churches either of wood or of stone for their new disciples. These were evidently at first very rude

Digitized by Google

and homely structures, as we may perceive by the remains of many which carry with them, even to the present times, innate evidence of great antiquity.

It is not easy to determine which of those structures that have descended to our time is the oldest, nor is it necessary to do so in our present inquiry. Most of them are peculiarly rude and unfinished, as far as neatness of workmanship comes under such a definition; but of a soundness of material and cement, where cement has been used, that may defy, in point of durability, the best specimens of building at the present day.

Coeval with these structures, or according to General Vallancy much more ancient, are the *Turres Ecclesiasticæ*, or round towers. It is not the present purpose to speculate on the use of these lofty buildings, but we will assume that they were erected merely as steeples to the churches to which they were attached. If this supposition be correct, their erection must have been posterior to the erection of belfries or campaniles, which Dr. Ledwich and some other writers limit to the eighth or ninth century. Whether in this statement they are right or wrong I will not pretend to say. Perhaps if these towers be more ancient, we must adopt the theory that they were, previous to that invention, used as minarets are at present among the Musselmen. I can hardly bring myself to think with General Vallancy, that they were Persaic structures, dedicated to the fire worship of the sun For my own part I see no reason to doubt of their being Christian edifices, built immediately after the introduction of Christianity. Bells were invented, or rather in use, so early as the fifth century; and I imagine no good cause can be shown, why a belfry should not be an equally ancient appendage to the church. If, however, we adopt the General's hypothesis, we need set no narrow bounds to our imagination; for in that case we may date their origin as early as we please. Some writers imagine that they were penitentiary towers, the habitation of certain recluses called "Inclusi, or Cellant," erected in imitation of the pillar of St. Simon the Stylite, as he is called, of Syria. It was a favourite opinion of those who advocate his theory, that the penitent, as he grew in grace and sanctification, ascended higher in his tower, story by story, till he reached the summit, in order to hold a closer intercourse with the skies. Others assert that the penitent at first took his station at the top, and descended by degrees as his sins were remitted, till, on reaching the door, he obtained complete absolution, and was received into the body of the church by the officiating priest. The learned Harris and Dean Richardson were of this opinion; and Dr. Milner, adopting it on their authority, says—"it is impossible to show what other purpose they were calculated for, and that it is equally impossible to discover the vestiges of any other *Clusoriæ* in the neighbourhood of the great churches."

From this theory, though upheld by such learned antiquarians, I must venture to dissent. Dr. Milner seems to forget the existence of such "*Clusoriæ*" as the stone-roofed cells at Killaloe, Kells, and elsewhere, which were as obviously suited to the purpose as the towers; besides, cheaply as labour in those days could be procured, one of these towers would cost too much to the monastery, or the district, or whatever other community, civil or religious, might be then in being, to be thus devoted for the exclusive salvation of an individual, to the prejudice of many hundred pious souls, equally ardent in their aspirations after such superior sanctity and mortification. It is equally unlikely that the insulated individual, who had made a vow of poverty, could, from his own resources, or by his own exertions, erect such a pile for his own use.

The ascetic life held forth, or was supposed to hold forth, too many advantages to the numbers who embraced it, to permit the dispension of those benefits to be limited to so few as all the Irish towers together could accommodate. I can see no way of getting over the difficulty, except by supposing that the virtue of the anchorite's prayers and austerities was communicable to those who acquired an interest therein by contributing to his support; and who, in this way, were enabled to enjoy the merit of these austerities, which, it may be said, they thus performed by proxy. In this view no sacrifice of expense would be too great in return for such advantages. It is however very possible that the fanatic zeal which suggested such voluntary mortifications would also occasionally suggest these towers, if previously in existence, as very convenient retreats wherein to perform them; and to the solitary recluse the steeple tower would afford as comfortable a retirement as the cloistered cell. But whatever might be the uses of those towers, or for whatever purpose erected, in their masonry, which is at present our principal object, they rival the best specimens of church building in their vicinities, though many of those churches appear of a different, and frequently of a more recent kind of workmanship. Their rotund figure has not only tended to their durability, but proves incontestibly that the art of masonry had then attained a considerable share of perfection. To build to such an immense height, with rude stones—to give these towers the circular and taper form which most of them present, and to have their durability so well ascertained, as it has been to us, involves a degree of skill and a perfection of art for which, supposing churches and round towers the only stone buildings then in use, we can hardly account. The practice those masons would require to become expert at their business must, in my estimation, have been much more extensive. It may also be fairly questioned whether the best builders of the present day could erect a tower of similar dimensions and materials, which would last half their term.

The best opinion we can adopt as to their dates, is to suppose them the work of different ages; and accordingly, simple as was their form, we find various fashions prevail in their construction, and often a greater difference in the material of which they are built. In many of them the doors and windows are quite square, without the least approach to the arched form; in others the doors are circularly arched, and some of them assume the form of the Gothic pointed arch; so that without any abuse of the term, the round towers may be classed among our earliest Gothic structures.

From all these circumstances an attentive observer will perceive the gradual progress of the Gothic style of architecture, in its amalgamation with the original architecture of the country. Through this union, it was certainly at times debased by the mixture of the ruder alloy of the native architecture; and by this means, operating with other causes, the Gothic style was prevented from attaining that perfection of which it was susceptible, and which it did attain in England, and other countries more wealthy or more happily situated than our own.—*Thomas Bell.*

INSTITUTION OF CIVIL ENGINEERS.

J. Locke, Esq., M.P., President, in the Chair.

May 24.—The paper read was, "*On the Manufacture of Malleable Iron and Steel.*" By Henry Bessemer.

Attention was directed in the early part of the paper to the ordinary mode of manufacturing iron by the puddling process; in the course of which the iron, after it "came to nature," was gathered into balls, and was then removed as quickly as possible to the squeezer, where much of the fluid scoria, with other mechanically mixed impurities, was driven out, leaving a mass or billet of iron, composed of thousands of separate fragments of metal, the entire surface of every one of which was more or less coated with dry oxide, or fluid silicate of the oxide of iron. The great pressure exerted by the squeezer sufficed to so far remove the fluid coating of the contiguous particles, as to bring their surfaces into actual contact, and consequently to effect an union at such parts. But the whole of the matter thus displaced could not find its way between the interstices of the mass, and therefore it became locked in its numerous cavities, producing points of weakness and separation in the metal. No amount of after working or rolling could wholly displace the portions of cinder, dry oxide of iron and of sand, which thus became mixed up with and were diffused throughout the mass, causing flaws and cracks in the iron, all more or less objectionable.

Now, if these imperfections were the natural and inevitable consequences of the conditions under which malleable iron was at present produced, it followed that defects of a similar character must also of necessity exist in steel produced by the puddling process. The granular condition of the metal and its exposure to heat and oxygen could not fail, in both cases, to oxydise the entire surfaces of the numerous molecules to be united into one mass; the admixture of scoria and other matters from the furnace was equally certain to result; and also the difficulty of bringing each particle of the metal to the same degree of decarbonisation and refinement existed, as in the making of iron, with the additional inconvenience arising from some portions of the metal becoming entirely decarbonised, and being converted into soft malleable iron.

Iron thus presented a most unfavourable contrast with the other malleable metals, all of which were free from sand or scoria; they had no hard and soft parts, and required no welding together of separate molecules, but they were perfectly homogeneous, and free from all mechanical admixture with foreign substances. Gold, silver, copper, zinc, tin and lead owed this valuable exemption from the defects universally found in puddled iron simply to the fact, that they were purified and refined in a fluid state, and while still fluid were formed into ingots, whereby the

Digitized by Google

cohesion of every particle in the mass was insured. If then the refining of other malleable metals while in a fluid state, and their formation into cast ingots, rendered all such metals more sound and homogeneous than iron, while it did not lessen their extreme ductility, why should iron for ever remain an exception to the general rule? It might be truly answered, that hitherto the excessively high temperature required to fuse and to maintain pure iron in a fluid state, had interposed an insuperable barrier, for the highest heat of the furnaces only sufficed to show that fluidity was a possible condition of that metal.

It need not therefore be a matter of surprise, that when Mr. Bessemer first proposed to convert crude pig iron into malleable iron while in a fluid state, and to retain the fluidity of the metal for a sufficient time to admit of its being cast into moulds, without the employment of any fuel in the process, his proposition was looked upon by many as a chimera, or as the mere day-dream of an enthusiast; but it was nevertheless fully recognised and supported by many of the scientific men of the day. The same deep conviction of the truth on which the new process was based, and which led Mr. Bessemer to bring it before the British Association in 1856, had since determined (in spite of the opinions then pronounced against the process) to pursue one undeviating course until the present time, and to remain silent for years under the expressed doubts of those who predicted its failure, rather than again bring forward the invention until it had been practically and commercially worked, and there had been produced by it both iron and steel of a quality which could not be surpassed by any iron or steel made by the tedious and expensive processes now in general use. The want of success which attended some of the early experiments was erroneously attributed by some persons to the "burning" of the metal, and by others to the absence of cinder, and to the crystalline condition of cast metal. It was almost needless to say that neither of the causes assigned had anything to do with the failure of the process in those cases where failure had occurred. Chemical investigation soon pointed out the real source of difficulty. It was found that although the metal could be wholly decarbonised, and the silicum be removed, the quantity of sulphur and of phosphorus was but little affected; and as different samples were carefully analysed it was ascertained that red shortness was always produced by sulphur, when present to the extent of $\frac{1}{10}$th per cent., and that cold shortness resulted from the presence of a like quantity of phosphorus; it therefore became necessary to remove those substances. Steam and pure hydrogen gas were tried, with more or less success, in the removal of sulphur; and various fluxes, composed chiefly of silicates of the oxide of iron and manganese, were brought in contact with the fluid metal during the process, and the quantity of phosphorus was thereby reduced. Thus many months were consumed in laborious and expensive experiments; consecutive steps in advance were made, and many valuable facts were elicited. The successful working of some of the higher qualities of pig iron caused a total change in the process, to which the efforts of Messrs. Bessemer and Longsdon were directed. It was determined to import some of the best Swedish pig-iron, from which steel of excellent quality was made, and tried for almost all the uses for which steel of the highest class was employed. It was then decided to discontinue for a time all further experiments, and to erect steel works at Sheffield, for the express purpose of fully developing and working the new process commercially, and thus to remove the erroneous impressions so generally entertained in reference to the Bessemer process.

In manufacturing tool steel of the highest quality, it was found preferable for several reasons to use the best Swedish pig-iron, and, when converted into steel by the Bessemer process, to pour the fluid steel into water, and afterwards to remelt the shotted metal in a crucible (as at present practised in making blister-steel), whereby the small ingots required for this particular article were more perfectly and more readily made.

It was satisfactory to know that there existed in this country vast and apparently inexhaustible beds of the purest ores fitted for the process. Of the hematite alone, 970,000 tons were raised annually, and this quantity might be doubled or trebled whenever a demand arose. It was from the hematite pig-iron, made at the Workington Iron Works, that most of the larger samples of iron and steel exhibited were made. About 1 ton 13 cwt. of ore, costing 10*s.* per ton, would yield 1 ton of pig metal, with 60 per cent. less lime, and 20 per cent. less fuel, than were generally consumed when working inferior ores; while the furnaces using this ore alone yielded from 220 to 240 tons per week, instead of, say 160 to 180 tons per week, when working with common iron stone. The Cleator Moor, the Weardale, and the Forest of Dean Iron Works, also produced an excellent metal for this purpose.

The form of converting vessel which had been found most suitable somewhat resembled the glass retort used by chemists for distillation. It was mounted on axes, and was lined with "ganister" or road drift, which lasted during the conversion of thirty or forty charges of steel, and was then quickly and cheaply repaired or renewed. The vessel was brought into an inclined position, to receive the charge of crude iron, during which time the tuyeres were above the surface of the metal. As soon as the whole charge was run in, the vessel was moved on its axes, so as to bring the tuyeres below the level of the metal, when the process was at once brought into full activity, and twenty small though powerful jets of air sprung upwards through the fluid mass; the air expanding in volume divided itself into globules, or burst violently upwards, carrying with it a large quantity of the fluid metal, which again fell back into the boiling mass below. The oxygen of the air appeared in this process first to produce the combustion of the carbon contained in the iron, and at the same time to oxydise the silicum, producing silicic acid, which, uniting with the oxide of iron obtained by the combustion of a small quantity of metallic iron, thus produced a fluid silicate of the oxide of iron, or "cinder," which was retained in the vessel and assisted in purifying the metal. The increase of temperature which the metal underwent, and which seemed so disproportionate to the quantity of carbon and iron consumed was doubtless owing to the favourable circumstances under which combustion took place. There was no intercepting material to absorb the heat generated, and to prevent its being taken up by the metal, for heat was evolved at thousands of points, distributed throughout the fluid, and when the metal boiled the whole mass rose far above its natural level, forming a sort of spungy froth, with an intensely vivid combustion going on in every one of its numberless everchanging cavities. Thus by the mere action of the blast, a temperature was attained in the largest masses of metal in ten or twelve minutes, that whole days of exposure in the most powerful furnace would fail to produce.

The amount of decarbonisation of the metal was regulated with great accuracy by a meter, which indicated on a dial the number of cubic feet of air that had passed through the metal; so that steel of any quality or temper could be obtained with the greatest certainty. As soon as the metal had reached the desired point (as indicated by the dial), the workmen moved the vessel, so as to pour out the fluid malleable iron or steel into a founder's ladle, which was attached to the arm of a hydraulic crane, so as to be brought readily over the moulds. The ladle was provided with a fire-clay plug at the bottom, the raising of which by a suitable lever allowed the fluid metal to descend in a clear vertical stream into the moulds. When the first mould was filled the plug valve was depressed, and the metal was prevented from flowing until the casting ladle was moved over the next mould, when the raising of the plug allowed this to be filled in a similar manner, and so on until all the moulds were filled.

The casting of large masses of a perfectly homogeneous malleable metal into any desired form, rendered unnecessary the tedious, expensive, and uncertain operation of welding, now employed wherever large masses were required. The extreme toughness and extensibility of the Bessemer iron was proved by the bending of cold bars of iron 3 inches square under the hammer into a close fold, without the smallest perceptible rupture of the metal at any part; the bar being extended on the outside of the bend from 12 inches to 16¾ inches, and being compressed on the inside from 12 inches to 7¼ inches, making a difference in length of 9½ inches, between what, before bending, were the two parallel sides of a bar 3 inches square. An iron cable, consisting of four strands of round iron 1½-inch diameter, was so closely twisted while cold, as to cause the strands at the point of contact to be permanently imbedded into each other. Each of these strands had elongated 12½ inches in a length of 4 feet, and had diminished $\frac{1}{10}$th of an inch in diameter throughout their whole length. There were also exhibited some steel bars 2 inches square and 2 ft. 6 in. in length, twisted cold into a spiral, the angles of which were about 45 degrees; and some round steel bars 2 inches in diameter bent cold under the hammer into the form of an ordinary horse-shoe magnet, the outside of the bend measuring 5 inches more than the inside.

The steel and iron boiler plates, left without shearing, and with their ends bent over cold, also afforded ample evidence of the extreme tenacity and toughness of the metal; while the clear even surface of the railway axle and piece of malleable iron ordnance were examples of the perfect freedom from cracks, flaws, or hard veins, which formed so distinguishing a characteristic of the new metal. The tensile strength of this metal was not less remarkable, as the several samples of steel tested in the proving machine at Woolwich Arsenal, bore, according to the reports of Colonel Eardley-Wilmot, R.A., a strain varying from 150,000 lb. to 162,900 lb. on the square inch, and four samples of iron boiler plate from 68,314 lb. to 73,100 lb.; while according to the published experiments of Mr. W. Fairbairn, Staffordshire plates bore a mean strain of 45,000 lb., and Low Moor and Bowling plates a mean of 57,120 lb. per square inch.

There was also another fact of great importance in a commercial point of view. In the manufacture of plates for boilers and for ship building, the cost of production increased considerably with the increase of weight in the plate; for instance, the Low Moor Iron Company demanded 22*l.* per ton for the plates weighing 2½ cwt. each, but if the weight exceeded 5 cwt. then the price rose from 22*l.* to 37*l.* per ton. Now with cast ingots such as the one exhibited, and from which the sample plates were made, it was less troublesome, less expensive, and less wasteful of material, to make plates weighing from 10 to 20 cwt. than to produce smaller ones, and indeed there could be but little doubt that large plates would eventually be made in preference, and that those who wanted small plates would have to cut them from the large ones. A moment's reflection would therefore show the great economy of the new process in this respect, and when it was remembered that every rivetted joint in a plate reduced the ultimate strength of each 100 lb. to 70 lb., the great value of long plates for girders and for ship-building would be fully appreciated.

At a time when the manufacture of ordnance occupied so large a share of public attention, it was interesting briefly to point out the great facility

Digitized by Google

which the Bessemer process afforded of forming masses both of malleable iron and of steel of a size suitable for the heaviest ordnance, without any welding together of separate slabs, or the more costly mode of building up the gun with pieces accurately turned and fitted together. Many attempts had been made to produce wrought-iron ordnance, and this object had been successfully accomplished in the case of the large gun produced at the Mersey forge. But however perfect this one gun might be, the time required to make it and its immense cost manifestly rendered it still a great desideratum to produce guns rapidly and cheaply, of a material equal to or greater in tensile strength than wrought-iron, and if possible free from the liability which that material had to flaws and to deterioration during its long exposure to a welding heat. It was believed that the Bessemer process supplied this desideratum; as masses of cast malleable metal could be produced of 10 or 20 tons in weight in a single piece, and two or three such pieces might be conveniently made by the same apparatus in one day. The metal so made might be either soft malleable iron or soft steel. In order to prove the extreme toughness of such iron, and the strain to which it might be subjected without bursting, several cast and hammered cylinders were placed cold under the steam hammer, and were crushed down without the least tearing of the metal, as was shown by the samples exhibited. These cylinders were drawn from a round cast-iron ingot of only two inches greater diameter than the finished cylinder, and in the precise way in which a gun would be treated; they might therefore be considered as short sections of an ordinary 9-pounder field-piece. The tensile strength of the samples, as tested at the Royal Arsenal, was 64,566 lb. per square inch, while the tensile strength of pieces cut from the Mersey gun gave a mean of 50,624 lb. longitudinally, and 43,339 lb. across the grain, thus showing a mean of 17,550 lb. per square inch in favour of the Bessemer iron.

If it was desired to produce ordnance by merely casting the metal, the ordinary founding process might be employed, with the simple difference that the iron, instead of running direct from the melting furnace into the mould, must first be run into the converting vessel, where in ten minutes it would become steel or malleable iron as was desired, and the casting might then take place in the ordinary manner. The small piece of ordnance exhibited served to illustrate this important manufacture; and it was interesting, in consequence of its being the first gun that was ever made in malleable iron without a weld or joint. The importance of this fact would be enhanced when it was known that conical masses of this pure tough metal, of from 5 to 10 tons in weight, could be produced at Woolwich, at a cost not exceeding 6*l.* 12*s.* per ton, inclusive of the cost of pig-iron, carriage, remelting, waste in the process, labour, and engine power. The conical ingots being cast in iron moulds, the great delay in moulding in loam would be avoided, and as the iron moulds employed might be removed from the casting pit within an hour after the metal had been poured into them, the tedious interval of three days now required by the cast-iron guns before removal would be also avoided, thus immensely increasing the capabilities of the foundry. If it was assumed that these advantages were about equal to the cost of hammering the cast ingot, then by this process it would be practicable to produce guns of any size, in hammered cast-steel or malleable iron, ready for the boring mill, at about the same cost as the cast-iron guns now in use; but if the weight of the guns could be reduced by 20 or 25 per cent., in consequence of their superior strength, then an actual saving in that proportion would be effected in the first cost of every gun so made. These important facts had been laid before the government, and their advantages were stated to be fully appreciated by Colonel Eardley-Wilmot, the superintendent of the Royal Gun Factories, who had evinced a great interest in the progress of the invention from its earliest date, and to whose kindness the author was indebted for the many valuable trials of the tensile strength of the various samples of metal that had been submitted for investigation.

It would be interesting to those who were watching the advancement of the new process, to know that it was already rapidly extending itself over Europe. The firm of Daniel Elfstrand and Co., of Edsken, who were the pioneers in Sweden, had now made several hundred tons of excellent steel by the Bessemer process. Another large manufactory had since been started in their immediate neighbourhood, and three other companies were also making arrangements to use the process. The authorities in Sweden had fully investigated the whole process, and had pronounced in favour of it. The large steel circular saw plate exhibited was made by Mr. Göranson, of Geffle, in Sweden, the ingot being cast direct from the fluid metal within fifteen minutes of its leaving the blast furnace. In France the process had been for some time carried on by the old established firm of James Jackson and Son, at their steel works near Bordeaux. This firm was about to manufacture puddled steel on a large scale. They had already got a puddling furnace erected and in active operation, when their attention was directed to the Bessemer process, the apparatus for which was put up at their works last year; and they were now extending their field of operation by putting up more powerful apparatus at the blast furnaces in the Landes. There were also four other blast furnaces in the South of France in course of erection, for the express purpose of carrying out the new process.

The irons of Algeria and Saxony had produced steel of the highest quality.

Belgium was not much behind her neighbours; the process was now being carried into operation at Liège, where excellent steel had been made from the native coke iron; while in Sardinia, preparations were also being made for working the system. Russia had sent to London an engineer and a professor of chemistry to report on the process, and Professor Müller of Vienna, and M. Dumas and others from Paris, had visited Sweden to inspect and report on the working of the new system in that country.

The Bessemer process might therefore be now fairly considered an accomplished commercial fact, and in a country like England, where the manufacture of iron and steel formed so important a branch of the national industry, and was so necessary an element in all the great manufacturing operations, it must be admitted that an impartial examination of the new system was of the highest importance, not only to those immediately concerned in the production of malleable iron and steel, but to the country generally.

That the process admitted of further improvement, and of a vast extension beyond its present limits, the author had no doubt; but those steps in advance would be imagined result chiefly from the experience gained in the daily commercial working of the process, and would most probably be the contributions of the many practical men who might be engaged in carrying on the manufacture of iron and steel by this system. Hitherto the process had been brought into its present practical and commercial state without recourse to any of the numerous inventions which were supposed by the several authors to be essential to the success of the system; but any real improvement that might be brought forward, would be cordially received and encouraged.

ON THE EFFICIENCY OF STEAM JACKETS IN STEAM ENGINES.*

By Gordon McKay.

There are many engineers of high standing who deny the efficacy of the steam jacket, and consider protecting the cylinder by non-conductors as the utmost limit to which it is possible to carry economy in this direction; and they argue with some plausibility, that the cylinder will require just as much steam to keep it at a certain temperature if heated from the outside by a jacket, as it will if heated by the steam used in the cylinder to propel the machinery; while the jacket, necessarily having a greater radiating surface, will radiate more heat externally, and hence prove a positive injury. To ascertain the economy of the steam jacket,—to what extent it is economical, and for what reason it is so, was the object of my experiments.

With this view I had a small steam engine and boiler made. The boiler was a vertical one, about 2 feet in diameter, and 6 feet high, having an internal fire-box and tubes. The engine was attached to the boiler, the cylinder being at its upper end, and placed above the water-line in the boiler; and the shaft and balance wheel below. The valve is what is known as the lap valve, so arranged as to cut off the steam at one-half stroke. The cylinder was 2 inches in diameter, and the stroke 8 inches; it was jacketed, and steam conveyed from the boiler to the jacket by a pipe, and the water condensed in the jacket carried back to the boiler by another pipe, discharging below the water-line into the boiler. Cocks were so arranged in these pipes that the steam could be cut off from the jacket altogether, or be admitted to it, and the condensed water returned to the boiler, or be taken from the jacket in a vessel and not returned to the boiler.

A dynamometer was applied to the balance wheel to measure the power, and a counter attached to the engine shaft to record its revolutions. A glass water-gauge indicated the height of the water in the boiler, and a graduated scale on the gauge the weight of water that the boiler contained. This scale was adapted to the expanded state of water at a temperature of 342°. The reservoir which supplied the force pump was placed on a platform scale, and the water taken from it to the boiler carefully weighed. The boiler had also a steam pressure-gauge, and during the experiments the pressure was maintained at 115 lb. with great accuracy. The exhaust steam of the engine was used to make the draught, which was regulated by a closely fitting door in the ash pit, by adjusting which the steam pressure could be regulated with great facility, a variation of one pound either way from 115 would cover the errors arising from that source. The cylinder of the engine was encased outside the steam jacket with cotton about 4 inches thick; and during the experiments the safety valve was not allowed to lift.

The engine when completed was kept in motion for about fourteen days, in order to get it in such a state that its friction and

* From the Journal of the Franklin Institute.

Digitized by Google

leakage would remain constant during the experiments; and care was taken that the oiling should be alike in each case.

The first experiment was made with steam in the jacket, the condensed water being returned to the boiler.

The pressure on the boiler was	115 lb.
The initial pressure in the cylinder	95 lb.

(This was obtained by indicator diagram.) The weight on the dynamometer scale 7½ lb., corresponding to about 1 horse power.

The duration of the experiment	8 hours
Revolutions made	97,440
Water evaporated from the boiler	485 lb.

By a subsequent experiment, the water returned to the boiler from the jacket was ascertained to have been 15·7 lb. for the 97,440 revolutions. Making the whole water evaporated 500·7 lb.

The second experiment, without steam in the jacket, was continued eight hours, but the number of revolutions was a little less than in the first case, and the results as to the water evaporated have been corrected to correspond with the number of revolutions in the first experiment, to facilitate comparison. The initial and boiler pressures the same as before; weight on dynamometer the same.

Duration of experiment	8 hours
Revolutions (corrected)	97,440
Water evaporated	630 lb.

These experiments were then repeated with sensibly the same results.

From a measurement of the size of the steam ports, clearance, and fill, of the cylinder, a computation of water (as steam) required to supply the engine for 97,440 revolutions, with 95 lb. pressure, gives 321 lb. Hence in the first experiment we have the following:—

Revolutions		97,440
Initial pressure		95 lb.
Boiler pressure		115 lb.
Water used in the engine, as computed	...321 lb.	
,, condensed in the jacket... ...	... 15·7	
,, used in leaks of joints, boiler, &c.	...164·0	
Total water evaporated ——		500·7 lb.

In the second experiment, without jacket, we have

Revolutions		97,440
Initial pressure		95 lb.
Boiler pressure		115 lb.
Water used in leaks of joints, as before	164 lb.	
,, used in the engine	466	
Total water evaporated ——		630 lb.

From the above it is evident that the water used in the engine and jacket was ... ... 321+15·7=336·7 lb.
While in the second, without jacket, the water used was ... 466

Showing a saving by the jacket of ... ... 129·3 lb.
Or if the leaks be added, the result is the same, 336·7+164=500·7 lb.
466·0+164=630

Difference ... ... 129·3 lb.

This result clearly shows the jacket to be economical, and in this instance the economy amounts to a saving of 129 in 466 of the necessary quantity of steam, if there had been no leaks; or of 129 in 630, with leaks to the extent of the present case; or about 27 per cent. without leaks, and about 20 per cent. with leaks.

The question arises, will this ratio hold good in all cases, and upon what principles is the saving by use of the jacket, or rather the waste (condensation) for the want of one, to be computed.

Trace the action of steam through one revolution of the engine. The valve is opened at the commencement of the stroke, and steam enters the port, and space between the cylinder head and the piston; all the surfaces surrounding these spaces are at a lower temperature than the steam, and a portion of it is condensed by imparting its heat to the surrounding surfaces. The piston now begins to move, and as it passes onward exposes new condensing surface to the steam, and more is condensed, and this process continues until the cut-off valve closes, and expansion of steam commences in the cylinder. At this point the cylinder is to a certain extent in the same condition as the boiler, containing steam and water, and as the piston advances and the pressure is decreased, the water in the cylinder is again converted into steam; and thus if the expansion is continued long enough the whole condensed water is re-evaporated. The exhaust valve now opens, and the return stroke of the piston is made, with a temperature of steam corresponding to the exhaust pressure. From these considerations it appears evident that condensation will be as the *extent of condensing surface up to the point of cut-off, and as the number of revolutions;* it will also doubtless be effectual by the difference of initial, final, and exhaust temperatures. Precisely what effect these temperatures will have I am at present unable to state, my experiments extending only to pressures, as stated before.

The steam condensed in the cylinder of a steam engine has been heretofore stated as a certain per-centage of the steam used, and attempts have been made to ascertain that per-centage for different degrees of expansion; but it is evident that if the condensation depends upon the condensing surface, no per-centage of the steam used can be given which will apply to cylinders of all sizes; as the ratio of condensing surface to the capacity of the cylinder will vary in almost every engine. Let the condensation then be computed per square inch per stroke, and in the present instance it will be found thus; the whole condensation is given as 129·3 lb., or 3581 cubic inches, which divided by the number of strokes, 194,880, is ·01837: this divided by the square inches of condensing surface which was rendered non-condensing by steam in the jacket, 23·55, gives the quantity as ·00078 cubic inches of water condensed by each square inch of unjacketed surface in the cylinder at any stroke of the piston; and this may be considered as correct for engines having initial and exhaust pressures corresponding to the one experimented upon, viz., initial, 95 lb., and exhaust, 17 above a vacuum.

In addition to the above method of ascertaining the condensation, I have obtained nearly the same result from a locomotive, where I had an indicator diagram taken with nearly the same initial and exhaust pressures, and where the condensing area and dimensions of the cylinder were known. The excess of water in the state of steam in the cylinder at the end of the stroke above that at the point of cut-off, as shown by the steam pressures at these points, amounted to ·0008 cubic inches per square inch of condensing surface; a quantity a little greater than that obtained in the experiment, yet so near as to be corroborative. It may here be remarked—as illustrating the truth of the assertion, that the condensation is as the surface and as the strokes, and not a per-centage of the quantity of steam used—that the ratio of condensing surface to the contents of the cylinder was in the experimental engine as 14 to 35, while in the locomotive it was as 16 to 12, and the revolutions as 200 to 168.

The next inquiry that suggests itself is, how can this saving in the use of the jacket be accounted for? I think the answer will be found in the fact, that if heat be taken from the steam inside the cylinder to maintain its temperature, the only heat that is available for that purpose is the sensible heat, that is, the difference of the temperatures due to the initial and final pressures; or in the experiment cited before 328°—220°=108°, 328° being the temperature of steam at 95 lb. pressure, and 220° that of steam of 17 lb. pressure. It may at first seem that the latent heat is applied to heating the cylinder, inasmuch as the steam is in part condensed, as shown by the diagram of the locomotive cylinder, and therefore its latent heat must be evolved. But it also seems from the locomotive diagram that the same water was reconverted into steam, thereby resuming its latent heat; hence the sensible heat is all that remains in the cylinder. While if the steam is used in the jacket, the latent heat is applied to the cylinder, and this amounts in the present instance to 1202°—342°=860°, 1202° being the total heat of the steam, and 342° the temperature of the water that was returned to the boiler from the jacket. If this solution of the question is correct, the product of the condensed water inside the cylinder multiplied into the temperature assigned to it should equal that of the water in the jacket multiplied into its temperature, or 129·3×108°=13,964, which should equal 15·7×860°=13,502. The result is not exact, but sufficiently so to induce considerable confidence in the theory.

The preceding experiments and deductions are not by any means sufficient to enable me to determine fully the laws which govern the condensation of steam in a cylinder,—they only fix one point for one degree of expansion, and one final and initial temperature; and in order to a full investigation of this interesting subject, more extensive experiments are necessary. They are however sufficient to show that the steam jacket is not a myth, but has a real value which can be accounted for on sound principles, and also that it is advantageously applicable to non-condensing as well as to condensing engines.

Digitized by Google

REVIEWS.

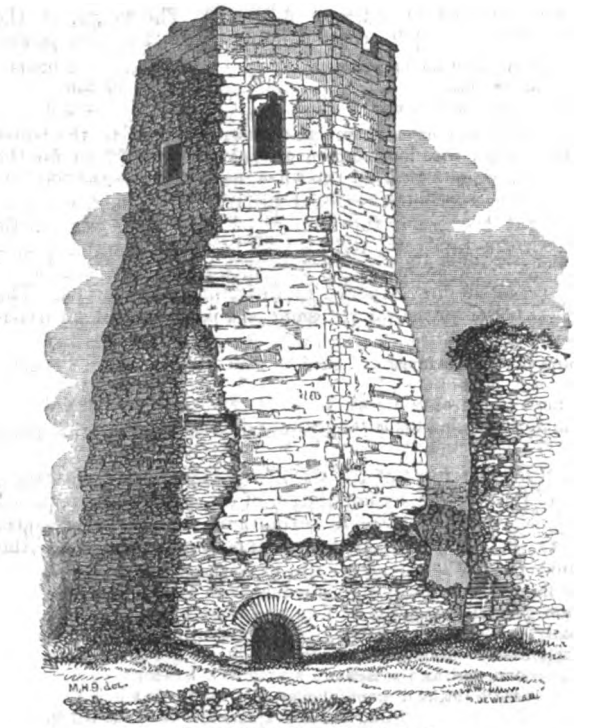
The Principles of Gothic Ecclesiastical Architecture. By M. H. Bloxam. Tenth Edition, 300 woodcuts.—London: Kent and Co.

Mr. Bloxam's 'Introduction to Gothic Architecture,' first published about thirty years ago, has been the pioneer to a succession of works which culminated perhaps in the issue of the universally-known Oxford 'Glossary' by Mr. J. H. Parker. Nevertheless the other treatises alluded to, especially those by Mr. Bloxam and Mr. Barr, are greatly useful in initiating the student into the principles of mediæval architecture, and, inasmuch as they are clearly and comprehensively written, they will doubtless hold their places as fitting companions to the more elaborate "Rickman." The "Bloxam" before us, while retaining its original handbook form, has swelled into a handsome octavo of more than double its former contents, numbering in this, its tenth edition, nearly five hundred pages, and three hundred woodcuts. These latter are excellent assistants to the text,—indeed they are indispensable, considering the nature of the work,—and a compendious glossary of terms, antiquarian and archæological, forms a suitable appendix to the volume. The established name of the author is a guarantee for the sterling value of the information afforded, and the style in which it is imparted is at once interesting and instructive. The general scope of the work remains nearly unaltered, though it has evidently undergone a thorough revision; and it has been enlarged by the addition of two entirely new chapters treating on the internal arrangement of churches, previous to and after the Reformation. This subject is elucidated by some curious engravings, copied from illuminated manuscripts, old painted glass, wall frescoes, &c. In investigating the true meaning of ancient architectural terms, recourse has been had to sundry working contracts for buildings, the documents concerning which are still extant, also to the wills of Kings Henry VI. and Henry VII., and the productions, among others, of Gervase of Canterbury, Matthew Paris, William of Worcester, and Leland.

The "centenary of ancient terms," which evidences great research, will serve as a key to the technical phraseology of the many documents of this kind to which reference is made.

As specimens of the woodcuts, or for the interest of the subjects, we introduce a few illustrations, and have added architectural descriptions to accompany them.

"In the fragments of Roman masonry left in this country we find certain peculiarities which are not to be met with even in the most ancient of the Anglo-Saxon remains, although the latter sometimes approximate to the Roman mode of building with arches formed of brickwork. Walls of Roman masonry were chiefly constructed of stone or flint, according to the part of the country in which one or the other material prevailed, imbedded in mortar, with pounded brick intermixed with the lime, and bonded at certain intervals throughout with regular courses or layers of large flat bricks or tiles, which, from the inequality of thickness and size, do not appear to have been shaped in any regular mould. The general average size obtained from the measurement of many of these bricks may be stated as being 15 inches long, 10 inches wide, and 2½ inches thick. Some bricks are found as much as 2 feet long, and some 3 inches thick. The thickness varies from ¾-inch to 3 inches. The Roman wall in the north, between Newcastle and Carlisle, appears to have been constructed wholly of stone without any admixture of brick, and is so far contrary to the mode of Roman construction in South Britain. Of the ruined structures of Roman workmanship still existing in Britain, one of the most remarkable is the portion of a wall at Leicester, near the church of Saint Nicholas, apparently the fragment of some Roman temple or basilica. This wall contains several arched recesses, the soffits or vaultings of which are turned with courses of large flat bricks; rows of these are likewise interspersed throughout the wall at intervals, as bonding-courses, and the Roman mode of constructing the arch with brickwork is here clearly displayed. According to Geoffrey of Monmouth, there was in Ratæ (*i.e.* Leicester) a temple of Janus, and it may be remarked that this ruin bears a striking resemblance in many points to the ruins of one of the ancient temples at Rome. On attentive examination, the east or interior side appears to have been exposed to the action of fire, as though the edifice of which it is a vestige was burnt. At Wroxeter, Salop, is a curious portion of a wall of similar construction, consisting of courses of stone with regular horizontal courses of brickwork at intervals, and remains of brick arches on one side, which indicate it to have formed part of a building, and not a mere wall, as it now appears. The Roman polygonal tower, near the ruined Anglo-Saxon church within the precincts of Dover Castle, notwithstanding an exterior casing of flint and other alterations effected in the fifteenth century by Erpingham, lord warden of the castle in the reign of Henry V., still retains many visible features of its original construction of tufa and flint bonded with bricks at intervals, some portion of the flint casing having been destroyed. Since the drawing for the accompanying engraving was taken, the ancient Roman doorway on the south side, forming the entrance into this tower, has been blocked up by a mass of masonry, so that access to the interior of the structure is cut off, and the constructive features of the doorway are hidden. A wanton act of Vandalism it is impossible too strongly to



Roman Tower, Dover Castle, Kent.

condemn! Roman masonry, of the mixed description of brick and stone regularly disposed, is found in walls at York, Lincoln, Silchester, Verulam, and elsewhere; and sometimes we meet with bricks or stone arranged herring-bone fashion, as in the vestiges of a Roman building, now destroyed, at Castor, Northamptonshire, and the walls of a Roman villa discovered at Littleton, Somersetshire. In the walls of Colchester Castle, which is of late Norman work, horizontal layers of Roman brick and stone are alternately interspersed: there is also a wall with several rows of bricks disposed herring-bone fashion. This structure exhibits perhaps a greater apparent resemblance to Roman masonry than any other of so late a period, but on close examination and comparison the difference is clearly discernible.

"The presumed remains of churches of early Anglo-Saxon antiquity, which on a comparative view most nearly approximate the Roman mode of building, consist of the ruined church at Dover Castle, which has often, though erroneously, been ascribed to the Roman era; and a much more perfect edifice, the church at Brixworth, Northamptonshire. The church within the precincts of Dover Castle presents features of early



Ruined Church, Dover Castle.

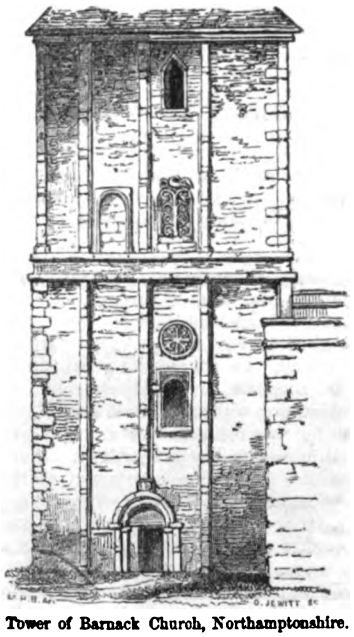
work approximating Roman, in a portal and window-arches formed of brickwork, which seem to have been copied from those in the Roman

Digitized by Google

tower adjoining; in the walls also much Roman brick is used, but they have no such regular horizontal layers as Roman masonry displays. The most ancient portions of this church may be referred to the seventh century. Eadbald, King of Kent, who died A.D. 640, was probably the founder. The shell only remains; it consists of a nave and chancel with north and south transepts, having a large square tower at the intersection; there is no staircase in the tower. It is difficult to ascertain satisfactorily whether it is an Anglo-Saxon or Anglo-Norman structure, as it contains details which are common to both those styles. In the west wall is a small semicircular-headed window, the arch of which springs from a plain square-edged impost of two members, the one projecting over the other, similar to the imposts of an Anglo-Saxon triple window in the east wall of the tower of Brixworth Church, and to a stringcourse in the same church of which a woodcut is given. The east and west arches of the tower are semicircular, and, with the jambs, are entirely composed of brick, with the exception of a few courses of stone below the imposts, and a single stone in the crown of the arch as a key-stone. The imposts are rudely moulded, and in some respects resemble Anglo-Saxon, and in others Anglo-Norman detail. The jambs are 3 ft. 6 in. thick, and in the west wall of the tower the arch is recessed. Some of the windows of the tower are semicircular-headed, with jambs straight-sided and without any splay. The tower also contains small circular windows, which are splayed both externally as well as internally; these windows are constructed of Roman brick. Within the last century the east and other windows in this church, which were of comparatively late insertion, have been entirely removed and filled up with masonry.

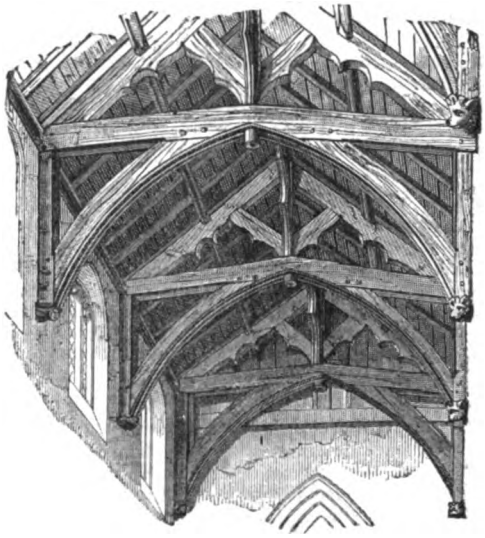
* * * *

"In most of the churches which contain vestiges of presumed Anglo-Saxon masonry we find the latter generally discernible by certain peculiar features in construction; for the walls, which are now commonly covered on the exterior with a coating of stucco or plaster, and were perhaps so covered originally, were chiefly formed of rubble or rag stone, having *long* and *short* blocks of ashlar work, or hewn stone, disposed at the angles in alternate courses, so as to form a tie or bond to the rubble work. We also see projecting a few inches from the surface of the wall, and running up vertically, narrow ribs or square-edged strips of stone, bearing from their position a rude resemblance to pilasters; and these strips are generally composed of long and short pieces of stone placed alternately. A plain stringcourse of the same description of square-edged rib or strip work often runs horizontally along the walls of Anglo-Saxon masonry, and this sometimes served as a basement on which the vertical ribs were set, and sometimes as a string up to which they were carried and beneath which they finished. The towers of the churches of Earl's Barton and Barnack, Northamptonshire, and of one of the churches at Barton-upon-Humber, Lincolnshire, are so covered with these narrow projecting strips of stone-work, that the surfaces of the walls appear divided into rudely-formed panels."



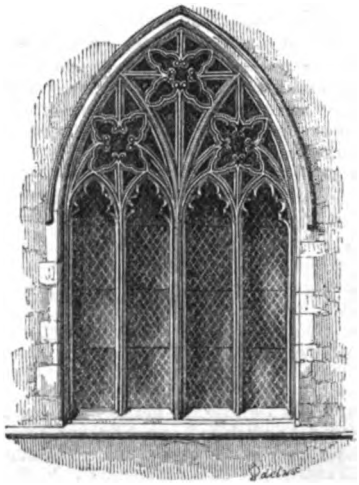
Tower of Barnack Church, Northamptonshire.

The roof of Adderbury Church is an excellent specimen of fourteenth century woodwork, an age of which comparatively few examples remain. The framing consists of moulded tie-beams with square king-posts, and struts or braces which support the principal rafters and purlins; the spaces between the rafters, struts, and tie-beams are foliated; beneath the tie-beams are curved bracing ribs with spandrels, which, with the wall pieces, spring from carved corbel heads; and longitudinal bracing ribs, disposed so as to form arches with cusped soffits, are carried from king-post to king-post. This roof is worthy of minute examination.



Roof, west end of Nave, Adderbury Church.

Of "Decorated" windows there is a great variety given. One of a very peculiar design is that from the east window of the chancel at Chartham, near Canterbury (see engraving); the side windows are each of two lights, the pattern consisting of half of that just mentioned.



Chartham, Kent.

"In large conventual churches, circular windows filled with tracery are not uncommon; these are sometimes found in small churches, as at Milton Malsor Church, Northamptonshire; Leigh Church, Cheshire; and in the tower of the church of Stratford-upon-Avon. At the west end of the south aisle of Alderbury Church, Salop, is a fine triangular spherical-shaped window filled with tracery."

In the chapter on the "Internal arrangements of churches previous to the Reformation" will be found some very curious information relative to church furniture and customs during the middle ages. Allusion is made to the different kinds of liturgical offices which successively came into use, to the religious structures used for worship by the ancient British church, of which there are a few and brief notices in the works of St. Chrysostom and Gildas, and of which the altars therein only are mentioned, while of the structures themselves we have now no visible traces. The uses of the *fenestella* or "stoup," the piscina, the sanctus-bell, are then described, also the history of pulpits and pews in churches.

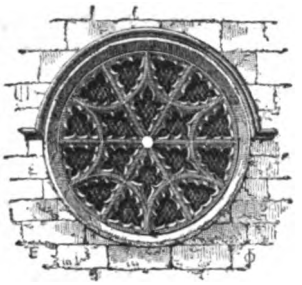
"Anciently the body of the church appears to have contained no other fixed seats for the congregation than solid masses of masonry raised against the walls, and forming long stone benches or seats. Benches of

Digitized by Google

this description, 14 inches high and 12 inches wide, run along the north, west, and south walls of the little Norman church of Parranforth, Cornwall; a structure only 25 feet long and 12 ft. 6 in. in width. In the Norman conventual church, Romsey, Hants, plain stone benches of this description occur; they are likewise to be met with in Salisbury and other cathedrals; and in not a few of our ancient parish churches.

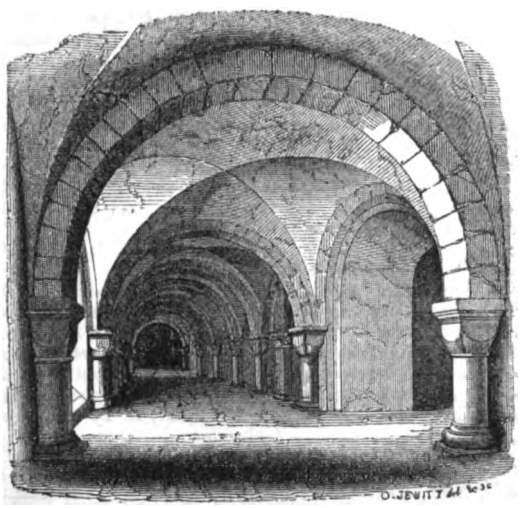
* * * *

"Open wooden benches or pew-work are rarely, if at all, met with of an earlier era than the fourteenth century, and even during that era the examples left are comparatively few. At Finedon, in Northamptonshire, the body of the church and aisles are almost entirely filled with low open seats with carved tracery at the ends, disposed in four distinct rows, so that the whole of the congregation might sit facing the east. These appear to be of the fourteenth century. The church of Byfield, in the same county, and the little interesting church of Shotswell, Warwickshire, both contain their original fittings of pew-work, of the fourteenth century. To the same period we may ascribe those capital plain specimens of ancient pewing with which the beautiful church of Hawton, Lincolnshire, is filled. But it was in the fifteenth century that the practice of pewing the body of the church with low open seats generally prevailed. We find examples in this era varying from extreme plainness to excessive richness.



Leek Church, Staffordshire.

"The pulpit was anciently disposed towards the eastern part of the body of the church, but not in the centre of the aisle. Pulpits are now rarely to be found of an earlier date than the fifteenth century, when they apear to have been introduced into many churches, though not to have become a general appendage. Ancient pulpits of that era, whether of wood or stone, are covered with panel-work tracery and mouldings; and some exhibit signs of having been once elaborately painted and gilt. Mention, however, is made of pulpits at a much earlier period; for in the year 1187 one was set up in the abbey church, Bury St. Edmund's, from which, we are told, the abbot was accustomed to preach to the people in the vulgar tongue and provincial dialect. The most ancient pulpit, perhaps, existing in this country, is that in the refectory of the abbey (now in ruins) of Beaulieu, Hampshire: it is of stone, and partly projects from the wall, and is ornamented with mouldings, sculptured foliage, and a series of blank trefoiled pointed arches, in the style of the thirteenth century. In the refectory of the ancient conventual buildings attached to the cathedral church at Chester, is another ancient stone pulpit, apparently of the thirteenth century.



Crypt, Canterbury Cathedral.

"In the choirs of cathedral and conventual churches, and in the chancels of some other churches, a moveable desk, at which the epistle and gospel were read, was placed: this was often called the eagle desk, from its being frequently sustained on a brazen eagle with expanded wings, elevated on a stand, emblematic of St. John the Evangelist. Eagle desks are generally found either of the fifteenth or seventeenth century; notices of them occur, however, much earlier."

The subject of stained glass is adverted to with considerable ability, and numerous examples are quoted of the several kinds of treatment, especially in subject-groups.

"The subjects portrayed on the glass were sometimes scriptural, sometimes legendary. Single figures of saints, distinguished by their peculiar symbols, are common; figures of crowned heads, prelates, and warriors also frequently occur; and on some windows are depicted the arms and sometimes even the portraits of different benefactors to the church, with scrolls bearing inscriptions....The era of the various specimens of ancient stained glass we meet with in our churches may generally be ascertained by the costume and disposition of the figures, the form of the shields, the mosaic pattern or other back-ground, and architectural designs of the canopies."

It is impossible within our limits to refer otherwise than in the most cursory manner to the subject of glass painting as practised in the present day. Mr. Winston has done good service to the cause in his admirable work published some years ago. The want of simplicity of treatment, the overloading with colour, the want of breadth or balance of colour, the deficiency in a proper intermixture of *white* glass, the frequent use of too many colours, the overshading by stippling, the over-ornamentation in minute accessories, the false principle of treating glass painting in the same light as oil paintings, with occasional attempts at aerial perspective, together with a want of proper archaic knowledge of design and predominating tone of colour, with reference to the architectural style of the church in which the glass is to be introduced, are faults which require to be amended before a more chaste and correct style can be attained to.



Sepulchral Cross, Bakewell, Derbyshire.

The Mason's, Bricklayer's, Plasterer's, and Decorator's Practical Guide. Parts 1, 2, 3, and 4. Edited by R. Robson.—London: James Hagger.

We purposely deferred noticing this work at the commencement of its issue in order that we might be better able to judge from an inspection of a few numbers in what way and with what probable measure of success the author is likely to deal with so comprehensive a plan. Of course the great difficulty in works of this nature is to condense as closely as may be consistent with utility those preliminary topics which of necessity must be touched upon, and which for this reason are uniformly reiterated in works of this class with more or less elaboration. For instance, those commonplace axioms which have received mathematical definitions, or those geometrical problems which every schoolboy can solve and apply, come within the scope of the elementary department of science; and since it is on these enunciations that the main principles of construction, and especially masonry, are founded, Mr. Robson does well neither to take them wholly for granted nor to dilate upon them with undue technicality or precision. We have in our mind at the present moment the explanation given of the principles of the *ellipse*, and the different methods ordinarily resorted to for describing it, in the fourth number of this book, and illustrations such as this may be taken as a fair sample of the whole: indeed, as a practical man, the author has treated his subjects throughout in a practical manner, leaving theory and speculation for the most part out of the question. Again, in

Digitized by Google

referring to those oft-repeated topics in which it is all but impossible to discover an unbeaten track, though of course one can recognise here and there the sources whence certain portions have been derived, there is sufficient variety infused into the original matter, and the whole is so traced down to the latest discoveries, that in a comparatively small space is comprised the essence of many elaborate treatises.

The first number is naturally devoted to an exemplification of the various modes of constructing foundations (a subject which would have admitted of more consideration here); and by the commencement of an article on the different kinds and qualities of stone, marble, and alabaster, concerning which some excellent hints are given.

"We must direct the attention of our readers to the important fact, in reference to all buildings constructed of Portland stone, that their elevations which are exposed to a southern aspect decay much sooner than those facing the north, as will be observed on examination of Somerset House, and other buildings in London. This, however, is not confined to Portland stone buildings, nor to any particular climate in which they are situated, for it holds good as applied to all stones in which there is any percentage of lime in their composition. Thus, York Minster, which is built of magnesian limestone, is much more decayed on its southern than its northern façade."

As a remedy for this, it is suggested to "saturate the southern fronts of limestone buildings by Ransome's patented process." We are not disposed to commit ourselves exclusively to this preparation, or indeed, in the present state of things, to any: experiments have been made with tolerably satisfactory results in other ways, both on simple blocks of stone, and on some of our modern public buildings, such as the New Houses of Parliament and Westminster Abbey. Some year or two back, also, we detailed length the process which has been found so serviceable in arresting the decay of the stonework of some of the royal tombs within the last mentioned fabric.

"The next stone that has been extensively used in the public and private buildings of the metropolis has been supplied from the quarries in the vicinity of Bath, and bears the universal name of 'Bath stone.' There are a great many varieties of it, good, bad, and indifferent. Bath-stone is generally composed of 94·50 per cent. of carbonate of lime, and 2·50 carbonate of magnesia, and is soft when first quarried, so much so that it can be cut into shapes required by ordinary toothed saws, carpenters' chisels, gouges, and drags, which is not the case with sandstones, the working of which involves much more labour, effected in a great measure by the mason, with his mallet and chisel. The best qualities of Bath stone are those from what are termed the Combe Down, the Corsham Down, and Box-hill quarries, the last of which, when well selected, endures remarkably well; and, being of a much softer nature than Portland stone, offers greater facilities for its formation into moulded work and enrichments of various descriptions.

"Of other soft stones, we may enumerate the purely magnesian lime combinations, the principal of which comes from Mansfield, in Nottinghamshire, and Caen, in Normandy. Caen stone is of a beautiful cream colour, close in its texture, and when well selected, is admirably adapted for internal works, as altars and reredoses of churches, pulpits, fonts, capitals, &c., where strength is not required. Its fine grain, colour, and facilities of working have induced its application *externally* to buildings, which unfortunately has proved an entire mistake, it having now been indisputably proved that this stone will not resist the climate of England more than fifteen years. Other purely oolite stones have also been tried in some of the modern buildings of the metropolis, all of which have proved more or less unsuccessful; if we except three different qualities from the Mansfield quarries.

"Another stone, imported from Aubigny, of the same class, is of a still superior quality to that from Caen; but, being much dearer, it has not been brought sufficiently into use to test its resistance to the weather when applied externally. It appears to be something of the hardness and quality of the Portland stone, but much more uniform in its texture, of an agreeable colour, and admirably adapted for monumental and internal works when strength and precision of finish are required, as it is capable of retaining very fine arrises, and when elaborate carvings are to be executed, an edge may be obtained equal to Sicilian marble."

"We must not omit to name a most important building material much lost sight of in modern practice, but which can be recommended as one of the most valuable that has yet been introduced in London, namely, *Sicilian Marble*. This valuable marble is known in Italy as *Bianco Chiaro*, in France *Blanc Clair*, and in America as *Ordinary*. Like statuary marble, it is found in large quantities in the noted quarries at Carrara; and we can assign no special reason for its particular nomenclature, considering it a misnomer. It is believed, however, that the first blocks imported into England were shipped at Leghorn, in a vessel which afterwards called at a port in the island of Sicily to complete the cargo, and on her arrival thence, the marble not being distinguished by any name in the invoice, was called Sicilian. It is of a white ground with the addition of a greyish tint, particularly when first quarried, but has the advantage of becoming much whiter on being exposed to atmospheric influence externally, and without any diminution of its hardness. It is admirably adapted for monumental purposes, garden decorations, statues, vases, and superior external architecture generally.

"On the continent, Sicilian marble is extensively used for the exterior decoration of palaces, chateaux, and public buildings. In proof of its durability in England, what is called 'The Marble Arch'—standing on the site of Tyburn Gate, at the western end of Oxford-street, as one of the principal entrances to Hyde Park—may be named. It was executed upwards of thirty years ago, and still remains without any symptoms of surface disintegration or decay. This arch was constructed at the quarries of Carrara, from the designs of the late Mr. John Nash, the favourite architect of George IV., and is adorned with sculpture by the celebrated Flaxman, exhibiting, as a whole, one of the best examples of Sicilian marble work in the metropolis, although the detail is wanting in originality, and the whole work lacks that degree of magnificence which ought to distinguish a triumphal arch worthy of a great nation. The edifice was removed from the front of Buckingham Palace some years ago, and fixed in its present position; but, notwithstanding the rough usage which it underwent during the transmission and re-setting, its individual parts remain comparatively uninjured."

To this succeeds a useful tabular list of the above materials, giving respectively their nature, colour, weight per cube foot, and price in London. Much of this information may be gleaned of course from other sources, and in this respect the analytical results of the commission employed to visit all the stone quarries of the kingdom that might be deemed advisable, previously to selecting materials for the Houses of Parliament, has proved an interesting and valuable document.

We should add to our enumeration of subjects treated of—an illustrated chapter on the theory of mouldings—ingeniously accommodated (perhaps too much so) to "rule of thumb" principles;—an examination of the various properties of artificial stone, and terra-cotta. In connection with these matters our author remarks—

"There are four principal kinds now in use, viz.,—Coade's, Ransome's, Blashfield's, and Buckwell's Granitic Breccia Stone. The first was invented by the late Mr. Coade, about three-quarters of a century ago, and manufactured very extensively by him, in conjunction with Mr. Seeley, at their large establishment in the Belvedere-road, Lambeth. In connection with this, it is noteworthy that Bacon, the celebrated sculptor, was employed by the proprietors to furnish models of statues and other works to be executed in the material, which in addition to its application to ornamental purposes, is admirably adapted for the formation of chimney shafts, and other architectural works in exposed situations, the constituent parts of which it is composed being much more durable than most kinds of natural stone.

"The basis of Mr. Coade's composition is a peculiar sort of clay, blended with crushed stone-bottle ware, flint, and other ingredients, the whole being mixed to the consistency of modeller's clay, and pressed into plaster moulds to the thickness of about one inch. After the mould was removed, the model was finished, placed in an ordinary pottery kiln, and turned out as a terra-cotta.

"One of the best examples of Mr. Coade's work is, probably, the frieze of the principal cornice of Buckingham Palace, which was executed about thirty years ago. It is what is termed *winding foliage*, interspersed with the rose, thistle, and shamrock, as the national emblems. We believe that Mr. Coade was the first who introduced artificial stone to any great extent in England; and at one period, even within our own recollection, he employed a great number of expert workmen, amongst whom were some excellent modellers, who executed fountains and statuary for ornamental grounds, with a considerable amount of ability. The establishment, however, was broken up a few years ago, and most of the large stock of models were sold by auction.

"The artificial stone invented by Mr. Frederick Ransome, is called *Ransome's Patent Siliceous Stone*. Mr. T. H. Henry, F.S.A., observes that 'it resembles in appearance and composition a *sandstone* of the best quality, being very similar in many of its properties to the celebrated Craigleith stone.' The specific gravity of the material in a dry state is 2·471. According to Professor Faraday, one of the greatest chemists of the age, the artificial stone under consideration is formed by particles of sandstone grit, combined with the silicate of soda, by whose tenacious properties, when fused, they are held together, as by a kind of glass enveloping the particles.

"It will thus be seen that the siliceous stone, like most artificial stones, is neither composed of clay nor lime; in fact, it is a siliceous or flint stone, the particles of which it is made up (fine pure sand) being united by a fluid, which, after exposure in a moderately heated kiln, become changed into a kind of indestructible glass; and by the nature of the processes which it undergoes it may be called a homogeneous composition, rivalling the best natural stones."

* * * *

Digitized by Google

"In modern times Michael Angelo and other great sculptors worked much in terra-cotta, and Bramante and other eminent architects were in the habit of introducing it profusely on the façades of some of their buildings, as may be seen in numerous examples at Rome, Ferrara, Bologna, Venice, Pisa, and Milan. These productions are generally of a pale red colour, and mostly of a sculptural class. They have not been moulded, as is the practice at the present day in England, but no doubt were modelled expressly by the artist, and sent direct to the kiln to be baked. Holbein, and others also earlier than his time, introduced the material into England, in the reigns of Henry VII. and Henry VIII.

"The Devon clay is used for making terra-cotta in combination with other clays: it is more soapy, and contains a greater quantity of alumina than the clays found in the vicinity of Stamford. The Poole clay is employed in the same manner and for similar works as the Devon clay, principally in the formation of fountains, tazzi, and articles of large diameter."

Some consideration is given to the several modes of constructing "arches," with an examination of their comparative strength; there is also an excellent plate illustrating the setting out of the masonry and filling-in of "Gothic vaulting,"—one of the most intricate and difficult questions that fall within the mason's art. There is also to be a chapter on "Domes," and another on the construction of stone staircases, geometric and ordinary; these are important questions, and but little understood in modern practice. We shall therefore look forward with interest to discussion respecting these and sundry other matters which have yet to come under consideration.

HERR CARL WERNER'S WATER-COLOUR DRAWINGS, 49, PALL MALL.

Good drawings in water-colours are universal favourites; and in the want of such as possess the highest merit, even those drawings which can but aspire to comparative excellence have their admirers. A large number of the pictures which our English artists yearly exhibit at the galleries of the two Societies of Painters in Water-Colours are in a greater or lesser degree tainted with the "opaque colour" delusion. A specious effect is thereby obtained with much facility, and pictures produced after this mode are both showy and attractive. But this is not legitimate painting in water-colours, more especially when it is borne in mind that body colours are liable to lose gradually their original aspect, and to fade away into dull and uniform monotony of hue.

This method of painting is, however, wholly ignored by a German artist, Herr Werner, who, for five years, has exhibited annually a selection of his own works in his *atelier*, at 49, Pall-mall. This exhibition is now on view by invitation from the artist, and is well worthy of examination. The collection numbers twenty-five pictures, among which will be found an effective interior of the House of Lords, and two views in Westminster Abbey. But the majority are scenes abroad, viz., at Venice, and the adjoining island of Torcello; from Norba, in the Pontine Marshes; from the Alhambra; the townhalls of Leipsic and Lubeck, Verona, Meissen in Saxony, Spalatro, and other places in Dalmatia. The subjects comprise architecture, landscape scenery, and figures, each of which is handled with great ability. It appears that the artist's plan is to devote the last month of the summer and the entire autumn to a sketching and painting tour. He finishes his various pictures during the winter, and with the return of spring he revisits this country, to lay the results of his labours before those who may feel disposed to honour him with a visit.

STRENGTH OF GUNS AND OTHER CYLINDERS.

Extracted from an Account of some Experiments elucidating the Theory on which the Author founds his Patented Method of Manufacturing Cannon; also of the Endurance of some Guns and other Cylinders made to Test the Practical Value of this Method.—Read at the United Service Institution, by Captain Blakely, R.A.

These experiments were made by Major Wade, of the U.S. Ordnance, for his government, which has been so liberal as to publish them, together with many other most interesting and valuable researches, in a book entitled 'Reports of Experiments on Metals for Cannon.'

In 1846 Major Wade, when testing some muskets by hydrostatic pressure, found the elasticity of sound barrels such, that a column of water in them 21 inches high could be diminished half an inch by a pressure of 2000 lb. A column of water 39 to 40 inches high be shortened $\frac{7}{8}$ of an inch with a pressure of 2400 lb. When the pressure was removed the water recovered its original height nearly.

This result cannot have been owing to the compression of the water, which would have been imperceptible with such a slight pressure; the musket barrels, therefore, must have increased in diameter during the strain.

In 1851 Major Wade measured the change in size of some hollow cast-iron cylinders when strained from within by hydrostatic pressure. Not only were they all enlarged during the continuance of the pressure, but *in every case an addition of pressure produced an increase of diameter.* The second column of the accompanying table gives the actual measurements by Major Wade of the diameters of these cylinders when strained by the force mentioned in the first column. The uniformity of the result in such a number of cases is nearly conclusive.

Extension of Hollow Cylinders.

Cylinder No. 1.

Force applied.	Diameters in inches.		Ratio of increment to the original diameter.		Outside less stretched than inside.	Thickness of metal.	Area of cross section.
	Interior.	Exterior	Interior.	Exterior			
lb.							sq. inches
0,000	·8050	1·3090	One in	One in	As one to	·2520	·83681
1,000	·8061	1·3093	732	4367	$5\frac{1}{10}$	·2516	·83603
2,000	·8083	1·3100	277	1309	$4\frac{3}{4}$	·25085	·83463
3,000	·8102	1·3110	155	655	$4\frac{1}{4}$	·25040	·83432
4,000	·8114	1·3120	126	437	$3\frac{1}{2}$	·25030	·83486
5,000	·8126	1·3130	107	327	$3\frac{1}{13}$	·25020	·83429
6,000	·8141	1·3140	88	262	3	·24995	·83554
7,000	·8153	1·3150	78	218	$2\frac{8}{10}$	·24985	·83607
					Average $3\frac{1}{4}$		
Cylinder No. 2.							
0,000	·8030	1·812	...	...	...	·5045	2·0723
5,000	·8030	1·812	...	...	...	·5045	2·0723
8,000	·8053	1·813	349	1812	$5\frac{1}{2}$	·50385	2·0722
10,000	·8067	1·814	217	906	$4\frac{1}{2}$	·50365	2·0733
12,000	·8085	1·815	146	604	$4\frac{1}{4}$	·50325	2·0739
14,000	·8110	1·816	100	453	$4\frac{1}{8}$	·50250	2·0736
					Average $4\frac{1}{8}$		
Cylinder No. 3.							
0,000	·8100	1·8120	...	...	...	·50100	2·0635
5,000	·8100	1·8120	...	...	...	·50100	2·0635
8,000	·8124	1·8127	337	2588	$7\frac{3}{5}$	·50015	2·0624
10,000	·8137	1·8130	219	1812	$8\frac{1}{4}$	·49915	2·0616
12,000	·8151	1·8134	159	1294	$8\frac{1}{4}$	·48915	2·0609
14,000	·8171	1·8140	114	906	8	·49845	2·0600
					Average 8		
Cylinder No. 4.							
0,000	·8070	1·811	...	...	...	·50200	2·0644
5,000	·8124	1·812	149	1811	$12\frac{1}{4}$	·49980	2·0604
8,000	·8166	1·814	84	604	$7\frac{1}{3}$	·49870	2·0606
10,000	·8177	1·814	75	604	8	·49815	2·0593
12,000	·8205	1·815	59	453	$7\frac{3}{5}$	·49725	2·0585
14,000	·8211	1·815	57	443	$7\frac{3}{4}$	·49695	2·0578
					Average $8\frac{1}{8}$		

The column in this table headed "thickness of metal" was calculated by me from Major Wade's data, the size of the inner and outer diameter. We here find that each increase of strain diminished the thickness of the tube.

The table of Major Wade's experiments proves that in No. 1 cylinder, where the sides were less than one-third of a calibre in thickness, the outer diameter was increased on an average $3\frac{1}{2}$ times less than the inner; and that in cylinders 2, 3, and 4, where the metal was $\frac{8}{8}$ of a calibre thick, the outside was stretched on an average seven times less than the inside.

In October 1844, Major Wade burst two 18-pounder cast-iron guns by hydrostatic pressure to find their strength. He afterwards carefully tested the strength of the metal to resist a direct tensile strain. One of these guns burst with a pressure of 9000 lb. per inch of resisting metal, yet a sample bar of the gun

Digitized by Google

showed a strength of 27,350 lb. per inch. The other burst with a strain of 6082 lb. per inch, whereas the sample showed a tensile force of 22,204 lb. Here we have proof that some part of the metal did not exert its strength, and that in each of these guns at least the useless part amounted to the great proportion of more than two-thirds of the whole.

In his report to the Colonel of Ordnance at Washington, Major Wade wrote on the subject as follows:—"The relation between the force applied in producing a fracture in cast-iron by a tensile strain in the axis of the specimen, and by that of hydrostatic pressure within the bore, appears to be somewhat greater than as three to one."

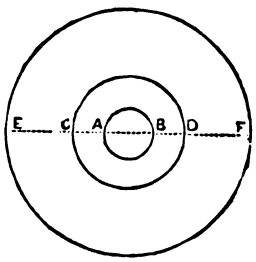
Another experiment made by Major Wade a few weeks later showed that it is the outside parts of cylinders which do not exert their strength. He turned down the outside of a 6-pounder cast-iron gun in a lathe to such an extent as to form, from the breech near to the trunnions, a cylinder of the uniform thickness of one calibre, that is to say, with a thickness of metal on every side equal to the diameter of the bore. He cut off the trunnions, and turned a second cylindrical portion in the middle of the gun with a thickness of half a calibre. In front he formed a third cylinder with metal only one quarter of a calibre thick. With a hydrostatic pressure of 12,400 lb. per square inch, the thin part burst in four fissures. The piston was then inserted in the middle part where the metal was half a calibre thick, and a pressure of 20,000 lb. burst it in three fissures, one of which extended 16 inches into the thick cylinder. In his report Major Wade wrote as follows:—"It appears from these results, that the power of resisting in cylinders of the same quality of iron, and of the same diameters of bore, but of different thickness, varies as the thickness, but in a less ratio. Hence the increase or the diminution of the thickness of iron in a gun does not increase or diminish the strength in like proportion. The results obtained in former trials by water-pressure with those now obtained from the 6-pounder gun are all given in the following table:—

Kind of iron.	By testing instrument.	By water pressure, per square inch.		Thickness of iron in parts of radius of bore.	Ratio of resistance by water pressure, the tensile strength being the unit = 1·000.
	Tensile strength per square inch.	Within the bore.	On the area of fracture.		
18-pounder No. 1 ...	27,350	9,000	9,000	1·000	0·329
18-pounder No. 2 ...	22,204	9,860	6,082	1·621	0·273
6-pounder ...	33,226	12,400	24,800	0·500	0·742
		20,000	20,000	1·000	0·602

Here we see that the 6-pounder, where only one-fourth of a calibre thick, required a pressure of 12,400 lb. per inch of bore to burst it; but that with double the thickness of metal, an addition of only 7600 lb. pressure, or about five-eighths of the former, sufficed to destroy it. The second equal thickness of metal, then, only exerted five-eighths as much power as the inner, the total strength being less than if they had been equally strained.

But the strength of the thinnest part was only in this experiment three-quarters (0·742) so much as if the whole of it even had been equally strained; the strength of the medium thickness therefore was only six-tenths, little more than half so much as if it had all been strained as much as the inside of all.

Any thick cylinder or tube may be considered as composed of several concentric smaller ones; and it is evident that each of these, by becoming thinner when stretched, loses some of its power of pressing the one above it. As an example, let us imagine a thick cylinder as composed of two concentric cylinders, accurately fitting, of which the inner one is exactly like No. 3 in Major Wade's experiment ·8100 inch bore, and 1·8120 inch in outer diameter, the latter being also the measure of the inner diameter of the outer tube. Now, referring to the table of the experiments, we find that on applying pressure from within until the inner diameter A B stretches from ·8100 to ·8124 inches, 1 in 337, the outer diameter of the inner cylinder would, if quite unopposed, only stretch from 1·8120 to 1·8127 inches, or 1 in 2588. But we now imagine over this tube another, which must resist its expansion, C D would therefore stretch less. To avoid theory, let us adhere however to Major Wade's figures, and say that C D would not stretch more than 1 in 2588, nearly eight times less than the inside. Evidently the inside of the outer cylinder would continue to touch the other, and must therefore stretch exactly as much; that is, 1 in 2588, the inside stretching 1 in 337. If the outer cylinder be of the same proportions as the inner, and of the same metal, we may fairly conclude that E F, its outer diameter, would stretch as much less than C D as C D stretched less than A B. This would only be 1 in 19,973, or sixty times less than A B.



The whole of our outer cylinder, therefore, could be very little strained when the inside was stretched 1 in 337. To stretch the inside more would endanger its soundness, and, however much we strain it, the outer cylinder will remain about eight times less strained, that is to say, will exert eight times less power than it. Major Wade found the result the same, whether he applied a small or a great pressure. When he stretched the inner diameter 1 in 114, which must have approached the point of rupture, the outside still only yielded 1 in 906.

The outer parts of a thick cylinder are almost precisely in the same condition of uselessness as if they formed a separate tube, fitted with perfect accuracy over an inner one; and the stretching of C D, the diameter of the middle part, will be as little in proportion to that of the inside, if the division of which it is the diameter is imaginary, as if it were real.

It is evident that if we could make the outer cylinder stretch as much with any given pressure as the inner, instead of eight times less, we should get eight times as much effective strength from it. This is easily done: *we have but to form the thick cylinder of two or more concentric ones; but, instead of making them so as to fit accurately, each must be slightly too small to go over the one underneath it without force.*

If, for example, over the inner cylinder we have been considering, whose outer diameter is 1·8120, we place another whose inner diameter is only 1·8074, or about $\frac{1}{400}$ of an inch less, then, when pressure from within enlarges the whole to such an extent that A B, the inner diameter of the inner tube, is stretched 1 in 337, and C D, its outer diameter, 1 in 2588, or from 1·8120 to 1·8127 (see table), the inner diameter of the outer cylinder will not, of course, be stretched beyond 1·8127; but, having been originally only 1·8074, this will suffice to strain it as much as the inside—53 in 18,074, or 1 in 337.

By this simple contrivance the outside could be made to perform in this case eight times as much work as if it were cast in one piece with the rest, or merely accurately fitted on.

When the outer diameter of the inner tube is stretched to 1·8127 inches, the inner diameter of the outer tube must also become 1·8127 inches. If it is originally 1·8120 inches, it is then extended 1 in 2588; but if only the $\frac{1}{400}$ of an inch less, or 1·8074 inches originally, then it is stretched 1 in 337.

We could, of course, regulate the extension of the two cylinders so as to be equal with any other amount of pressure; or we could make a greater number of cylinders, thin or thick, all expand equally with a certain amount of strain, by making the inside of each less than the outside of the one under it by a certain very small quantity.

Nothing is easier than to put one tube over another, though the outside of the lesser one be slightly larger than the inside of the other. The application of heat will expand the latter; and, when in position, the withdrawal of the heat will permit it to shrink and grasp the inner tube so tightly as to compress it. This operation is, however, uncertain in its effect; in practice, therefore, I would make the outer surface of one tube, and the inner surface of the other, slightly conical or tapering, and force one over the other with a hydrostatic press. The amount of strain and stretching can thus be accurately adjusted.

[The foregoing paper recommends the construction of cannons so that the material may be in a condition of permanent constraint, and that the relative strains may be so arranged that when the cannon is fired, the whole of the material may be subject to uniform tension. This is physically impossible, as was shown in the 19th volume of this Journal, p. 401. It is true that there is some economy of strength by constructing cannon

Digitized by Google

with external rings in a state of permanent tension. But that degree of economy which would be due to the supposed uniformity of tension under the action of an explosive force is unattainable. The fallacy of the arguments of Capt. Blakely and others who have advocated the same notion, is, that they omit the consideration that as each successive ring is put on so as to constrain the rest, it alters the tensions of all of them, and that those tensions vary according to a certain law, which is determined by the relations between the tangential and normal velocities of the metal, and cannot be arbitrarily altered.—ED. *C.E.*]

THE LIFE-BOAT AND CARRIAGE OF THE ROYAL NATIONAL LIFE-BOAT INSTITUTION.

THE accompanying figures show the general form, the nature of the fittings, and air-chambers of one of these boats, 30 feet in length and 7 ft. 6 in. in breadth. In Figs. 1 and 2, the elevation and deck plans, the general exterior form of the boat is shown with the sheer of gunwale, length of keel, and rake or slope of stem and stern-posts. The dotted lines of Fig. 1 show the position and dimensions of the air-chambers within board, and of the relieving-tubes. In Fig. 2, A represents the deck, B the relieving-tubes (6 inches in diameter), C the side air-cases, D the end air-chambers. In Fig. 3, the exterior forms of transverse sections, at different distances from stem to stern, is shown. Fig. 4 represents a midship transverse section, A being sections of the side air-cases, B the relieving-tubes, bored through solid massive chocks of wood of the same depth as the space between the deck and the boat's floor. C C are spaces beneath the deck, filled up, over 6 feet in length, at the midship part of the boat, with solid chocks of light wood, forming a portion of the ballast; D is a section of a small draining-tier, having a pump in it by which any leakage can be pumped out by one of the crew whilst afloat. The festooned lines in Fig 1 represent the exterior life-lines attached round the entire length of the boat, to which persons in the water may cling till they can be got into the boat; the two central lines are festooned lower than the others, to be used as stirrups, so that a person in the water by stepping on them may climb into the boat.

This life-boat possesses in the highest degree all the qualities which it is desirable that a life-boat should possess:—1, great lateral stability; 2, speed against a heavy sea; 3, facility for launching and for taking the shore; 4, immediate self-discharge of any water breaking into her; 5, the important advantage of self-righting if upset; 6, strength; and 7, stowage-room for a number of passengers.

The carriage consists of a fore and main body. The latter is formed of a keelway A, A, and of side or bilgeways B, B, in rear of the main axle, the boat's weight being entirely on the rollers of the keelway. Its leading characteristic is, that on the withdrawal of the long forelock pin C, the fore and main bodies can be detached from each other. The advantages of this arrangement are that the weight of the boat when she is launched from the rear end forms an inclined plane by elevating the keelway, yet without lifting the fore body off the ground, whilst to replace her on the carriage she can be hauled bow foremost up the fore end or longer incline. The bilgeways B, B, are needed at the rear end, that the boat may be launched in an upright position, with her crew on board; but they are not required at the fore end of the carriage. The boat is hauled off the carriage and launched into the sea by a rope on each side of the boat rove through the sheeve D, having one end hooked to a self-detaching hook at the boat's stern, and the other manned by a few persons on the shore, who thus haul the boat and her crew off the carriage, and launch them afloat at once, with their oars in their hands, by which means headway may be obtained before the breakers have time to beat the boat broadside on to the beach.

Fig. 1.—Sheer Plan.

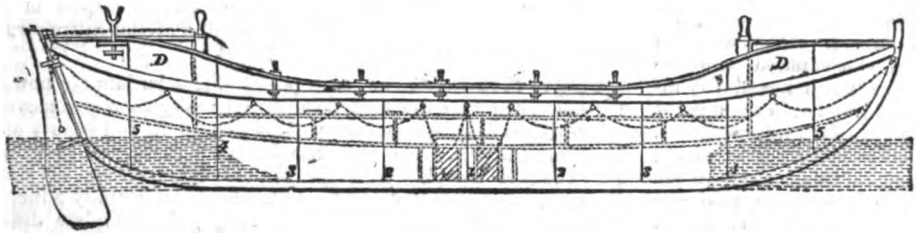


Fig. 2.—Deck Plan.

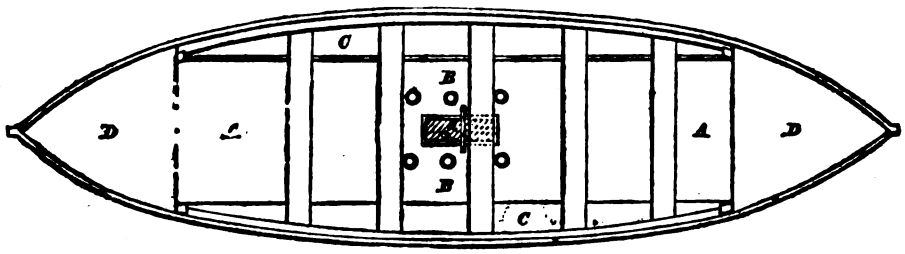
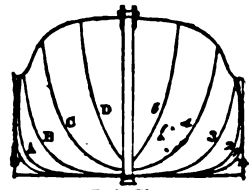


Fig. 3.

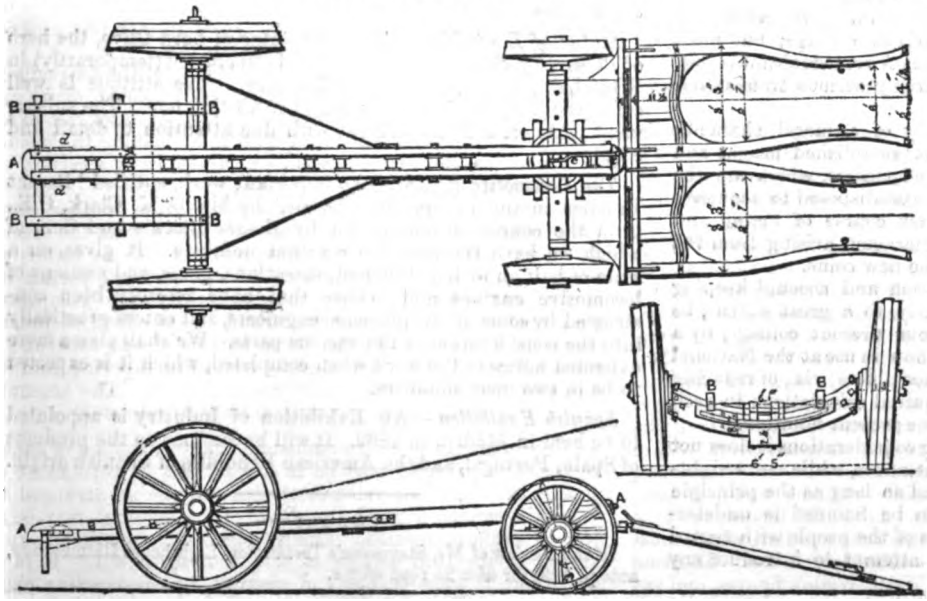


Body Plan.

Fig. 4.



Midship Section.



Digitized by Google

DECIMAL COINAGE.

THE Commissioners appointed to investigate how far it would be practicable and advisable to introduce the principle of decimal division into the coinage of the United Kingdom, have just issued their report, from which we extract the following:—

"The conclusions at which we have jointly arrived are embodied in the following resolutions:—

1. That the circumstances under which decimal coinage has been introduced in foreign countries, although affording both instruction and warning to us, differ in many important respects from those which exist in this country, and therefore no safe conclusions for our guidance can be drawn from the example, more or less satisfactory, of other countries.

2. That there appears to be no approach to unanimity of opinion on the question of the introduction of decimal coinage, in the commercial or other classes of the community.

3. That it is very difficult to come to any useful conclusions as to the merits of the decimal principle in the abstract.

Distinct and peculiar difficulties attend each separate form in which it has been proposed to introduce the decimal principle into the coinage of the country. A decimal coinage founded on the penny necessarily ejects the pound sterling, whilst a decimal coinage founded on the pound must involve all the inconveniences attending the abandonment of the penny.

4. That although many important advantages would attend a decimal coinage founded on the penny as compared with the pound and mil scheme, yet that a coinage which necessarily involves the disturbance of the pound sterling would, in the present state of public feeling, be unadvisable, and in fact, impracticable.

5. That the pound and mil scheme is the only form in which, under the present state of public feeling in this country on the question, the introduction of the decimal principle into our coinage can be contemplated with any reasonable probability of sufficient support.

6. That as regards paper calculations there appears to be a preponderance of advantage on the side of decimal coinage; but the extent of the superiority in that respect may be the subject of much difference of opinion.

7. That as regards the comparative convenience of our present coinage, and of the pound and mil scheme, for the reckonings of the shop and the market and for mental calculations generally, the superiority rests with the present system, in consequence principally of the more convenient divisibility of 4, 12, and 20, as compared with 10, and the facility for a successive division by 2, that is, for repeated halving, in correspondence with the natural and necessary tendency to this mode of subdividing all material things, and with the prevalence of binary steps in the division of our weights and measures.

8. That as regards the comparative convenience of the coins provided by the rival systems, the advantage appears to rest with our present coinage.

9. That the particular form of decimal coinage proposed as the pound and mil scheme cannot be looked upon as a well-assured or demonstrated improvement on our present coinage; but must rather be considered as an experiment of very doubtful result, accompanied beyond all question by many serious transitional difficulties.

10. That these difficulties are partly of a moral character arising from the violent disturbance of established usages and habits, especially amongst the uneducated classes, which are the least qualified to comprehend, and the least disposed to acquiesce in, such disturbance of their customary course of acting and thinking; and partly of a mechanical character arising from the non-interchangeability of the old and the new coins.

11. That the advantages in calculation and account-keeping anticipated from a decimal coinage may, to a great extent, be obtained without any disturbance of our present coinage, by a more extensive adoption of the practice now in use at the National Debt Office, and in the principal assurance offices; viz., of reducing money to decimals, performing the required calculations in decimals, and then restoring the result to the present notation.

12. That duly weighing the foregoing considerations it does not appear desirable under existing circumstances, while our weights and measures remain as at present, and so long as the principle on which their simplification ought to be founded is undetermined, to disturb the established habits of the people with regard to the coins now in use, by a partial attempt to introduce any new principle into the coinage alone."

NOTES OF THE MONTH.

Lighting Public Galleries.—We understand that in order to have an authoritative investigation into the whole question of lighting public galleries with gas, the Lord President of the Council has named a commission of inquiry, consisting of Professors Faraday, Hofmann, and Tyndall, with Mr. Redgrave, R.A., and Captain Fowke, R.E., who will commence their investigations immediately.

Architectural Congress.—An Architectural Congress is to be held in the ancient town of Stamford on the 6th and 7th September. The Lincolnshire, Northamptonshire, Leicestershire, Oxfordshire, and Bedfordshire societies will assemble on the occasion, which promises to offer many features of attractive interest on points connected with archæology and ecclesiology. The several old churches of Stamford, each of which is a very fine specimen of its particular style, are to be inspected on the first day, and the second is intended to be devoted to excursions in the neighbourhood, including the Roman excavations in Apthorpe Park, Fotheringhay Castle, King's Cliffe Church, &c.

Wivenhoe, Essex.—The alterations which have been for some time in contemplation for the improvement of this church have just been commenced. The principal works will consist of an extension of the south aisle, and the refitting of the entire structure. The estimated cost is about £1200.

Cologne Cathedral.—The south portal of this building is now so far completed that the scaffolding will be very shortly removed, when this elaborate structure will be seen in its full beauty and imposing features. The work has for many years been progressing towards completion under the superintendence of Herr Zwirner, the accomplished architect, who has faithfully adhered to the carrying out of the original design, the complete drawings for which are in existence.

Cawthorpe, Lincolnshire.—The foundation-stone of a new church at Little Cawthorpe was laid on the 6th ult. The appointed architect is Mr. R. J. Withers. The building is to be entirely of brick inside and out, and without any plastering whatever. The church is simple in plan, consisting of a nave and chancel only. A vestry, porch, and bell-turret will, however, form important features in the general effect. The seats are, of course, to be open.

Submarine Telegraph between Boulogne and Folkestone.—The Submarine Telegraph Company's new cable between Boulogne and Folkestone was successfully submerged on the 26th ult. The cable is the largest and strongest yet constructed. It contains six conducting wires of gauge No. 1 surrounding a hempen core; these wires are covered with hemp, and the whole is enclosed in 12 iron wires of gauge No. 0; the weight per mile amounts to just upon 10 tons. After submersion perfect signals were interchanged upon all the six conducting wires. The cable was manufactured and laid by Messrs. Glass, Elliott, and Co., the contractors.

Statue of Lord Clive.—A bronze statue of Lord Clive, the hero of Plassy, by Baron Marochetti, has been erected (temporarily) in Whitehall-gardens, facing the Treasury. The attitude is well conceived, and the figure is altogether a noble one. The subservient parts are also carried out with due attention to detail and effect.

The Locomotive Engine.—An important work, entitled 'Recent Practice in the Locomotive Engine,' by Mr. D. K. Clark, C.E., is in the course of publication by Messrs. Blackie and Son, of which we have received the six first numbers. It gives, on a scale of half an inch to the foot, elevations, plans, and sections of locomotive engines and boilers that have recently been constructed by some of our principal engineers, and enters practically into the consideration of the various parts. We shall give a more extended notice of the work when completed, which it is expected to be in two more numbers.

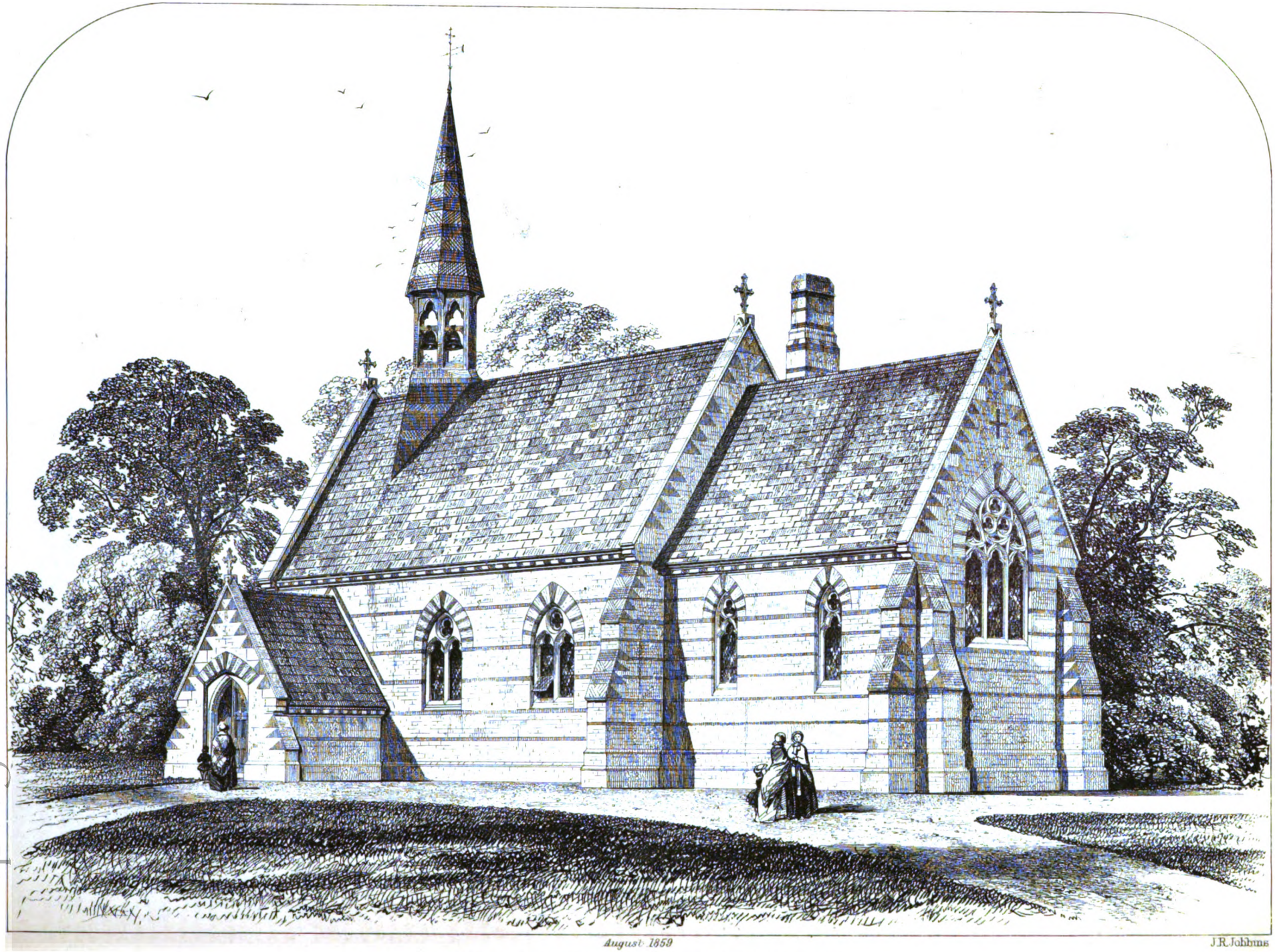
Spanish Exhibition.—An Exhibition of Industry is appointed to be held in Madrid in 1862. It will be confined to the products of Spain, Portugal, and the American Republics of Spanish origin.

ERRATUM.

In the Review of Mr. Stevenson's Treatise on Lighthouse Illumination, ante p. 193, for $ah = 2a$ read $ah = a$.

Digitized by Google

Digitized by Google



August 1859 J.R.Johnns

CHURCH OF S^{T} JOHN BAPTIST, ENFIELD, MIDDLESEX

J.P. S^{T} AUBYN, ARCH^{T}

Digitized by Google

CHURCH OF ST. JOHN THE BAPTIST, ENFIELD, MIDDLESEX.

(With an Engraving.)

THE Church of St. John the Baptist, Clay-hill, Enfield, recently erected, consists of chancel, 25 feet by 16 feet; nave, 50 feet by 21 ft. 6 in.; vestry, with organ chamber over, 12 feet by 8 feet; south porch 10 feet by 10 feet; and turret for two bells on apex of nave roof.

The structure is of brick, faced externally and internally with the same material; black and red bricks disposed in bands, diapers, &c. being employed successfully as a polychromatic decoration to finish the interior of the church, without the use of plaster, and to give character to the exterior. Bath stone was used for the dressings to windows, doors, and gables only. The whole floor surface of the church is paved with Minton's tiles; chairs alone being provided for the congregation. The chancel is furnished with handsome oak sittings for the choir, and through the liberality of some members of the congregation the church is well provided with altar hangings, brass standards for lighting, and other fittings. The pulpit is of brick and stone and paved with tiles, and is placed in the north-east angle of the nave near the chancel arch. The font is of stone with oak cover and is placed at the west end of the nave.

The entire cost of the church, including the formation and inclosure of the site, amounted to £1799 19*s.* 6*d.*, exclusive of architect's charges. It was erected from the designs and under the superintendence of Mr. J. P. St. Aubin, of John-street, Bedford-row, London.

THE NEW GOVERNMENT OFFICES.

IN our number for March last, we noticed the (as it appeared to us) somewhat strange and mal-a-propos opposition which had been excited in the House of Commons against the selection of Mr. Scott as the architect, and of his proposed adaptation of pointed architecture for the new Government Offices. As the only member of the Royal Academy among the direct competitors, as a recipient of the Royal medal last year, and as the victor in two great European competitions in a foreign country, there could seem no *primâ facie* objection to this appointment; and when a select committee had reported on the equality in merit, both as to style and design, of the three first premiated designs, and recommended that the choice should be made by government authorities from among the architects who had produced them, it appeared, to say the least, singular, that members of the House, and still more that members of that committee, should complain that the advice thus given had been acted on, merely because they might individually wish it to have been otherwise exercised.

Lord John Manners, the then First Commissioner of Works, on that occasion promised, that, before asking for a vote on the building he would exhibit the working drawings in one of the libraries of the House, and that the estimate he should bring forward would be the actual sum at which a builder would engage to execute the work;—a mode of proceeding forming really an era in the history of estimates for public buildings, and for which we have to thank Mr. Hunt, who for the last few years has acted as surveyor to the Office of Works.

These working drawings are now arranged for exhibition in the way alluded to, and are illustrated by a model, and by several views of the building. The design resembles that sent in originally in competition, as to its general distribution, and in the two buildings inclosing a large quadrangle from 280 feet by 200 feet—common to the two. The space of ground covered is 500 feet by 300 feet, the end towards the Park being occupied by the Foreign Office, and that towards Parliament Street by the India Office, and the quadrangle being entered by large and lofty gateways from Downing Street and Charles Street. The Foreign Office is considerably reduced in area from the former design, but the India Office is fully as large as what was at first proposed for the War Office. The design of both is greatly simplified, from which operation they do not appear to have much suffered, at least in general effect. In internal arrangement the Foreign Office is peculiarly simple,—a single corridor running through the centre of the building, with rooms on either side. The official residence is much reduced, and the suite of reception rooms, instead of being devoted wholly to that purpose, is proposed to be used also for various practical objects connected with the department, by which considerable economy has been effected. Internally, the most striking feature is the principal staircase, supported by a lofty central pillar, from which springs the rich groining of the ceiling.

The India Office (in the designing and erection of which Mr. Digby Wyatt, the official architect to that Board, is associated with Mr. Scott), the arrangements are necessarily much more multifarious and intricate, while the larger bulk of building necessitates internal courts for light; and these, with the grand staircase, have been arranged with due regard to architectural effect, both as to massing and details. The two together would form a noble group, and, whether viewed externally or internally, would be among the most remarkable architectural achievements in the metropolis.

It will be observed in them, that, without losing sight of a general principle of uniformity, the external design is nevertheless made everywhere to result from the necessities of the interior: the positions of the windows are decided not so much with regard to external effect, as with reference to the rooms they light; and even the heights of stories will be found to vary in parts to suit internal convenience. This is (when kept within the bounds of reason and taste) the true principle upon which every building should be designed, and that for which the Gothic style of architecture offers such great facilities. The internal arrangements of each building have been contrived, we understand, in strict accordance with the demands of the practical heads of the several departments.

We hail this as inaugurating a satisfactory variety from our ordinary cold and monotonous-looking buildings, and we sincerely congratulate the architects on the energy and skill with which they have brought their work so nearly to a stage for the actual commencement of building operations.

The mass of general and detail drawings exhibited is really surprising, and well worthy of close examination. It can scarcely be doubted that the design will upon the whole produce a favourable impression, and the more so, since it is clear that practical considerations have been most carefully studied, and modern requirements provided for. Nevertheless, we still hear rumours of an objection to the "style," on the part of some individuals high in office; though it may be hoped that, on further consideration, such unfavourable impressions may be removed, and that the country may not lose the vast amount of thought, of labour, and of money which have been expended upon these drawings, nor this most noble opportunity of introducing a bold variety from the stereotyped *status quo* of our civil architecture. Surely, when the competition was open as to style, when the select committee had reported the styles to be equal in all practical advantages,—and when one of them was selected, and the country put to considerable expense in acting upon it, there will be great cause for dissatisfaction if a change should take place at this advanced stage of the business.

HAWARDEN CHURCH, FLINTSHIRE.

THE church at Hawarden, as an ancient structure, was, from various causes, one of the most noted in North Wales. In October 1857, however, the beautiful edifice was nearly wholly destroyed by fire, a circumstance the more to be deplored, inasmuch as it had within a very recent period undergone a thorough repair and refitting at a considerable outlay. A survey of the damage done, and an estimate of the renewed expense that would probably be incurred, was made, and a return was handed in stating that at least £4000 would be required to reinstate the building in a suitable manner. A large proportion of this sum being speedily raised, the work was commenced forthwith, it being determined that the character of the architecture should in every detail exactly correspond with the type of the ecclesiastical building of the latter part of the thirteenth century. The preparation of designs was entrusted to Mr. Scott, of London, and the practical carrying of them out was undertaken by Mr. James Howes, who now resides in the locality.

The work commenced in earnest rather more than a twelvemonth ago, and progressed quietly but expeditiously until a few weeks since, when the undertaking was completed, and the church re-opened on the 14th ult. The essential features of the former

Digitized by Google

structure have been rigidly followed in the new one, the principal addition being a dwarf spire on the tower—which is a central one —35 feet in height, with four spire lights at the foot, thus rendering the building a still more conspicuous object from a distance than formerly, although owing to the elevated site it had always been a kind of landmark. In the interior the galleries have been removed, and at the north-west corner of the chancel an organ-chamber has been built. The church is cruciform, with north and south aisles to the nave, which latter is three bays in length, and has arches springing from massive octagonal columns of Runcorn stone, which are new, though the arches have not been restored. The floors of the nave and aisles are laid with Minton's red and black tiles, the pavement of the chancel being enriched with encaustic tiles. The roofs are of Dantzic oak, substantially framed, and covered with lead, the only exception being the roof over the east end of the chancel, which is an arched and panelled ceiling of oak, enriched by tracery, and covered with green Welsh slate.

The stained glass windows which had been put in not long previous to the fire, and which were sadly blackened and disfigured, have been perfectly renovated, and in the "Whitley" chancel a new stained glass memorial window has been inserted as a memorial to Captain Deans Dundas, late of the Coldstream Guards, for some time an M.P. for the county, and who died in 1836. This window, which is of three lights, has for its subject Ary Schœffer's "Christus consolator," and it has been worthily executed by Wailes, of Newcastle. The Whitley chancel has also been portioned off by a screen, which enables it to be used as a vestry. At the junction of the nave and chancel, on the north side, stands the pulpit, which is octagonal on plan, and constructed of white Painswick stone, relieved by Devonshire marble, procured near Plymouth. The front panel bears the sacred monogram, and on a side panel is carved the Agnus Dei. The font corresponds with the pulpit in material and style; and its carving with that of the pulpit is of good character, sculptured by Herley. The lectern is a carved oak eagle, executed in Oxford, and was presented by Sir Stephen R. Glynne, the brother of the rector. The sittings are open seats running along the nave and aisles; they are of solid appearance, and have square ends containing sunk quatrefoils, which are filled in with sprigs of natural foliage, the patterns of which are ingeniously diversified. Accommodation is afforded for about 650 persons, being an increase of nearly 60 sittings on the former building, notwithstanding the removal of the galleries.

The ornamental metal work, which deserves especial commendation, and includes some elaborate hinges for the chief entrance door, has been executed by Mr. Leaver, of Maidenhead, Berks. The tower has been under-pinned, and strengthened, a new floor of oak put in, and the peal of six bells re-hung by Messrs. Mears, of Whitechapel. It is computed that the expenses involved in the present undertaking, from first to last, amount in round numbers to about £6000.

Reclamation of Land from the Sea.—The reclamation from the sea of 700 acres of low marshy land near the port of Wells, Norfolk, has been progressing for the last two years. For this purpose a great embankment, involving an outlay of about £12,000, has been carried from the Holkham side of Wells in a straight line towards the sea, which has been, it is hoped, effectually shut out by this means from the land sought to be reclaimed. The bank forms a marine road of considerable width, is 1 mile and 132 yards long, and upwards of 20 feet in height. With the view of assimilating the bank to an ordinary beach, the slope next the sea for the first 15 feet of the height is five to one, while for the remainder of the elevation attained it is only four to one. It is not expected that ordinary tides will rise higher than the point at which the five to one slope terminates; but as the tides sometimes attain an extraordinary height at Wells, flowing over the quay, and almost drowning the inhabitants, the bank has been carried up about 7 feet more. The embankment has already had the effect of increasing the scour, and consequently deepening the channel in the harbour, and it is expected that ships of a greater burden will now be enabled to get up. The engineer is Mr. Arthur Saunders, and Mr. J. Buxton, the contractor. Further works of a similar character are contemplated in the direction of Stiffhey and Blakeney, between which places and Wells about 3000 acres await reclamation.

RESTORATION OF NOTRE DAME, PARIS.

THE works in connection with the restoration of the Cathedral of Notre Dame were commenced in 1845, and were first employed upon the south side of the choir, which had been modified in consequence of the establishment of a sacristy towards the middle of the last century. On this side the edifice presented the appearance of a ruin. The western side was undertaken in 1847, and the exterior restoration of the choir was continued up to 1857, when it was terminated. From 1851 to 1852 the works were interrupted. Recommenced again in 1853, the labour of renovation was bestowed upon the exterior of the southern façade of the nave: in 1855 this portion was completed, and in 1856 the restoration of the northern façade was commenced.

During the present year the restoration of the interior of the choir has been undertaken, as well as the reconstruction of the central vault of the transept and the interior repair of the nave, both of which will be finished in 1865. Twenty years will have thus been required for the entire restoration of the building.

The choir is recovering its primitive form, the fine mosaic pavement of the time of Louis XIV. having been preserved, as well as the bronze statues of angels, the group in white marble, and the stalls of the same period, together with the kneeling statues of Louis XIII. and Louis XIV. It will be inclosed by a gilt iron railing, preceded by a sort of screen, of leaning height, and will be provided with a jubé for reading the Epistle and Gospel. All the windows will be of coloured glass and of grisailles. It is not intended to paint the interior of the cathedral. The pavement of the church will be of marble, and that of the chapels of carved stone, or of square encaustic tiles. The entire cost of these repairs will ultimately reach the sum of 8,650,000 francs (£346,000).

The Cathedral of Notre Dame formerly possessed, in the centre of the transept, a wooden spire covered with lead, which dated from the thirteenth century, and was pulled down in 1797, on account of its decayed condition. The new spire, which is of most beautiful construction, reaches to a height of 148 feet above the highest part of the roof; but this measurement is exclusive of the cross, which is rather more than 26 feet. From the pavement of the church to the vane on the spire the distance is 292 feet. The new spire, as was the old one, will be entirely covered with lead: it consists of one closed story, two open stories, and the pyramid, which is decorated with crocs and divers ornaments. The open galleries have balustrades; the carved arches rest on piles of small columns; and four of the angles of the spire, which is constructed as an octagon, are each supported by a large spur, visible on the outside, and ornamented with statues of the Twelve Apostles and the emblems of the Four Evangelists. These sixteen figures are of raised copper. The exterior decorations of the body of the spire are of lead, consisting of fine leafwork, of crocs or fleurons, of capitals, and of ornamental waterspouts. The weight of the leadwork is upwards of 180 tons. By the interior staircases it is very easy to reach the second story, which is a little below the level of the towers. The placing of the framework of the new spire was commenced on 14th February, and terminated on the 15th of May last, and the decorations are all in an advanced stage. The total expense of the spire will be upwards of 400,000 francs (£16,000).

The present architect of Notre Dame is M. Violet Leduc, who has suggested and ably carried out most of the measures taken for the preservation of this venerable edifice.

HENRY CORT AND HIS INVENTIONS.

THE following letter from Mr. Fairbairn, relative to the survivors of the Cort family, recently appeared in the *Times*; and, heartily concurring in its sentiments, we are anxious to assist in calling attention to it. We sincerely trust that something will be done for the survivors of the family commensurate with their just claims upon all interested in the iron trade, and upon the public generally.

"Sir,—On various occasions I have read with pleasure your notices of the inventions of Henry Cort, but regret to find that your able advocacy of his children's claims has not been properly appreciated either by the government or the public.

It is well known that the discovery of the art of puddling, piling, welding, fagotting, and rolling iron belongs to Henry Cort; and it is also

Digitized by Google

known that these processes have been carried on with great success and with great benefit to the country for the last 70 years. It is however perhaps not so generally known that Cort expended a fortune of upwards of £20,000 in perfecting his inventions, that he was robbed of the fruits of his discoveries by the villainy of an official in a high department of government, and that, cheated and persecuted, he was ultimately allowed to starve by the apathy and selfishness of an ungrateful country.

When these facts are borne in mind, and it has been ascertained that his inventions have conferred upon the country an amount of wealth equivalent to £600,000,000 sterling, and given employment to 600,000 of the working population of our land during the last three generations, we are surely justified in referring with pride to results of such vast importance, while we insist upon the duty which devolves upon the nation to rescue from penury and distress the descendants of such a benefactor.

An appeal was recently made through the pages of the *Encyclopedia Britannica*, but like all previous appeals it was barren of result. Once more, through the columns of the *Times*, I desire to give publicity to the fact that out of a family of 13 there are still living one son and two daughters of Henry Cort, whose united ages now exceed 200 years, and who are destitute of the most meagre comforts of life. Assuredly such a state of things should not be; in a country where charity is no boast such claims should need no other advocacy than publicity.

I offer through you, sir, a donation of £100 towards a national subscription for the relief of these aged persons. The leading ironmasters of the country will, I doubt not, fill up the lists with much larger sums. The case is one for prompt and generous relief. The government should do something, but, as in many former and noteworthy cases and things, I fear the assistance from that quarter will only be tendered when it is too late.

In this appeal for the benefit of a distressed family I have not noticed what is due to its founder's memory; but looking at the services he has rendered to the iron trade and our iron constructions, I venture to affirm that the name of Cort should find a place in the list of British worthies alongside the illustrious names of Watt, Arkwright, and Wedgewood.

I am, Sir, your obedient servant,

Manchester, July 19. WILLIAM FAIRBAIRN."

INSTITUTION OF CIVIL ENGINEERS.

THE Council of the Institution of Civil Engineers have awarded the following Premiums for Papers read during the session 1858-59, recently concluded:—

1. A Telford Medal to MICHAEL SCOTT, M. Inst. C.E., for his paper "Description of a Breakwater at the Port of Blyth, and of Improvements in Breakwaters applicable to Harbours of Refuge."

2. A Telford Medal to ROBERT MALLETT, M. Inst. C.E., for his paper "On the Co-efficients of Elasticity and of Rupture in Wrought-Iron, in relation to the volume of the Metallic Mass, its metallurgic treatment, and the axial direction of its constituent crystals."

3. A Telford Medal to HENRY BESSEMER, for his paper "On the Manufacture of Malleable Iron and Steel."

4. A Telford Medal and the Manby Premium in Books, to WILLIAM JOSEPH KINGSBURY, Assoc. Inst. C.E., for his paper "Description of the Entrance, Entrance Lock, and Jetty Walls of the Victoria (London) Docks; with Remarks on the Form adopted in the construction of the Wrought-Iron Gates and Caisson."

5. A Watt Medal to JAMES WARDROP JAMESON, Assoc. Inst. C.E., for his paper "On the performance of the Screw Steamship Sahel, fitted with Du Trembley's Combined Vapour Engine, and of the Sister Ship Oasis, with Steam Engines worked expansively, and provided with partial surface condensation."

6. A Council Premium of Books to THOMAS SEBASTIAN ISAAC, for his paper "On the Successful Working by Locomotive Power, over gradients of 1 in 17, and curves of 300 feet radius, on Inclines in America."

7. A Council Premium of Books to MATTHEW BULLOCK JACKSON, M. Inst. C.E., for his paper "Description of the Gravitation Water Works at Melbourne, South Australia."

REVIEWS.

The Two Paths: being Lectures on Art, and its application to Decoration and Manufacture. By JOHN RUSKIN, M.A.—London: Smith, Elder and Co.

There is always this satisfaction attending the perusal of Mr. Ruskin's works, that they are sure well to repay the trouble. For, however one may be compelled to dissent from some of his propositions and even postulates, and although he may be occasionally open to the imputation of inconsistency and illogical conclusions, there is on the other hand an abundance of wholesome doctrine and vigorous conceptions, clothed in the choicest and most inspiriting language. In this latter quality his writings possess an irresistible charm,—the sentences fit together with the greatest ease, while the expressions are so happily chosen and so clearly put, that scarcely any word could be exchanged for another with equal advantage. All this has not however been attained without, it appears, a due amount of labour; yet the *ars celare artem* is so well mastered, that the labour bestowed never betrays itself. "Even in fast speaking," says Mr. Ruskin, "I try to use words carefully; and any alteration of expression will sometimes involve a great alteration in meaning." And then he comments on the frequent inaccuracy of "hurried journal reports," of course referring to such cases as those in which the scribe or presiding genius tries his hand at curtailing or trimming to suit his own special purposes. Yet, after all is said and done, we are favoured in the work before us with the author's criticism on his own performances, which summing up as follows, the reader will make his own comment, and then be prepared for acquainting himself with the rest of the book.

"The thing so commonly said about my writings, that they are rather persuasive than just; and that though my 'language' may be good, I am an unsafe guide in art criticism, is, like many other popular estimates in such matters, not merely untrue, but precisely the reverse of the truth; it is truth, like reflections in water, distorted much by the shaking receptive surface, and in every particular, upside down. For my 'language,' until within the last six or seven years, was loose, obscure, and more or less feeble; and still, though I have tried hard to mend it, the best I can do is inferior to much contemporary work. No description that I have ever given of anything is worth four lines of Tennyson; and in serious thought, my half-pages are generally only worth about as much as a single sentence either of his, or of Carlyle's. They are, I well trust, as true and necessary; but they are neither so concentrated nor so well put. But I am an entirely safe guide in art judgment: and that simply as the necessary result of my having given the labour of life to the determination of facts, rather than to the following of feelings or theories. Not, indeed, that my work is free from mistakes; it admits many, and always must admit many, from its scattered range; but, in the long run, it will be found to enter sternly and searchingly into the nature of what it deals with, and the kind of mistake it admits is never dangerous—consisting, usually, in pressing the truth too far."

The book consists of a series of five lectures, delivered before different institutions, on the following subjects:—1. "The deteriorative power of conventional art over the nations," (which was an inaugural address delivered at the South Kensington Museum in the beginning of last year.) 2. "The unity of art" (part of an address delivered at Manchester). 3. "Modern manufacture and design" (delivered at Bradford). 4. "The influence of the imagination in architecture" (addressed to the Architectural Association); and, 5. "The work of iron in nature, art, and policy" (delivered at Tunbridge Wells.) In some appendices are additional notes on certain topics, which are handled in an essentially Ruskin-ish manner. The two illustrations on steel, which have been so exquisitely rendered by the engraver, deserve more than ordinary commendation.

But our readers may hardly see the connection between the subjects discussed in these several lectures, and the title under which they are now comprehensively issued. Nor is the relationship at all apparent till we discover a few prefaced sentences, such as these:—"Their aim is to set one or two main principles of art in simple light before the general student, and to indicate their practical bearing on modern design. The law, which it has been my effort chiefly to illustrate, is the dependence of all noble design, in any kind, on the sculpture or painting of organic form. This is the vital law; lying at the root of all that I have ever tried to teach respecting architecture or any other art..... I hope throughout the volume the student will perceive an insistance upon one main truth, nor lose in any minor direction of inquiry the sense of the responsibility which the acceptance of that truth fastens upon him; responsibility for choice, decisive and conclusive, between two modes of study, which involve ultimately the development, or deadening, of every power he possesses. I have tried to hold that choice clearly out to him, and to unveil for him to its farthest the issue of his turning to the right hand or the left. Guides he may find many, and aids many; but all these will be in vain unless he has first recognised the hour and the point of life when the way divides itself, one way leading to the Olive mountains—one to the vale of the Salt Sea. There are few cross roads, that I know of, from one to the other. Let him pause at the parting of THE TWO PATHS."

In working out his ideas, the author enunciates the following assertions on the nature of art generally:

Digitized by Google

"Art, followed as such, and for its own sake, irrespective of the interpretation of nature by it, is destructive of whatever is best and noblest in humanity; but nature, however simply observed, or imperfectly known, is, in the degree of the affection felt for it, protective and helpful to all that is noblest in humanity. You might then conclude farther, that art, so far as it was devoted to the record or the interpretation of nature, would be helpful and ennobling also. And you would conclude this with perfect truth.. ...Wherever art is practised for its own sake, and the delight of the workman is in what he does and produces, instead of in what he interprets or exhibits,—there art has an influence of the most fatal kind on brain and heart, and it issues, if long so pursued, in the destruction both of intellectual power and moral principle; whereas art, devoted humbly and self-forgetfully to the clear statement and record of the facts of the universe, is always helpful and beneficient to mankind, full of comfort, strength, and salvation.

* * * * *

"You have two characters in which all greatness of art consists:—First, the earnest and intense seizing of natural facts; then the ordering those facts by strength of human intellect, so as to make them, for all who look upon them, to the utmost serviceable, memorable, and beautiful. And thus great art is nothing else than the type of strong and noble life; for, as the ignoble person, in his dealings with all that occurs in the world about him, first sees nothing clearly,—looks nothing fairly in the face, and then allows himself to be swept away by the trampling torrent, and unescapable force, of the things that he would not foresee, and could not understand: so the noble person, looking the facts of the world full in the face, and fathoming them with deep faculty, then deals with them in unalarmed intelligence and unhurried strength, and becomes, with his human intellect and will, no unconscious nor insignificant agent in consummating their good, and restraining their evil. Thus in human life you have the two fields of rightful toil for ever distinguished, yet for ever associated; Truth first—plan, or design, founded thereon: so in art, you have the same two fields for ever distinguished, for ever associated; Truth first—plan, or design, founded thereon.

* * * * *

"You cannot fail to see how, throughout the history of this wonderful art—from its earliest dawn in Lombardy to its last catastrophe in France and England—sculpture, founded on love of nature, was the talisman of its existence; wherever sculpture was practised, architecture arose—wherever that was neglected, architecture expired; and believe me, all you students who love this mediæval art, there is no hope of your ever doing any good with it, but on this everlasting principle.....And whosoever pleads for it as an ancient or a formal thing, and tries to teach it you as an ecclesiastical tradition or a geometrical science, knows nothing of its essence, less than nothing of its power."

The lecture on the "Unity of art" chiefly appertains to painting. Velasquez and Titian are held up to unqualified admiration; and, among the moderns, Reynolds, Turner, and W. Hunt. Wilkie is thought little of; Prout inimitable in his way ("There will never more be any Prout drawings"); Cox and Dewint second-rate, compared with Turner; Callcott "a mere vulgar imitator of other men's high breeding."

"And that brings me to the question, perhaps the most vexed question of all amongst us just now, between conventional and perfect art. You know that among architects and artists there are, and have been almost always, since art became a subject of much discussion, two parties, one maintaining that nature should be always altered and modified, and that the artist is greater than nature; they do not maintain, indeed, in words, but they maintain in idea, that the artist is greater than the Divine Maker of these things, and can improve them; while the other party say that he cannot improve nature, and that nature on the whole should improve him. That is the real meaning of the two parties, the essence of them; the practical result of their several theories being that the Idealists are always producing more or less formal conditions of art, and the Realists striving to produce in all their art either some image of nature, or record of nature; these, observe, being quite different things, the image being a resemblance, and the record, something which will give information about nature, but not necessarily imitate it.....Therefore, now you have it in your choice; here are your two paths for you: it is required of you to produce conventional ornament, and you may approach the task as the Hindoo does, and as the Arab did, without nature at all, with the chance of approximating your disposition somewhat to that of the Hindoos and Arabs; or as Sir Joshua and Velasquez did, with not the chance, but the certainty, of approximating your disposition, according to the sincerity of your effort—to the disposition of those great and good men.....Noble conventional decoration belongs only to three periods. First, there is the conventional decoration of the Greeks, used in subordination to their sculpture. There are then the noble conventional decoration of the early Gothic schools, and the noble conventional arabesque of the great Italian schools."

There is much that might be noted in the other addresses, but the matter of each is so closely strung together, that it would be difficult to isolate passages without conveying an imperfect or perhaps an incorrect impression. The chapter on "iron" especially abounds in most original thoughts, and is eminently suggestive in various ways, although the writer observes that ironwork is not one of his "special objects of study." A few sentences, introductory to the practical view of the subject, we however extract. The author has been explaining the offices of the metal in the operations of nature, and then urges that the type thus given by the lifeless metal of the action of body and soul together, has nobler antitype in the operations of all human power.

"All art worthy the name is the energy—neither of the human body alone, nor of the human soul alone, but of both united, one guiding the other: good craftsmanship and work of the fingers, joined with good emotion and work of the heart. There is no good art, nor possible judgment of art, when these two are not united; yet we are constantly trying to separate them. Our amateurs cannot be persuaded but that they may produce some kind of art by their fancy or sensibility, without going through the necessary manual toil. That is entirely hopeless. Without a certain number, and that a very great number, of steady acts of hand—a practice as careful and constant as would be necessary to learn any other manual business—no drawing is possible. On the other side, the workman, and those who employ him, are continually trying to produce art by trick or habit of fingers, without using their fancy or sensibility. That also is hopeless. Without mingling of heart-passion with hand-power, no art is possible. The highest art unites both in their intensest degrees: the action of the hand at its finest, with that of the heart at its fullest."

In a slight review of some of the functions of this metal, reference is made exclusively to its operations as a *colouring* element: as an ingredient, for instance, in the various earths and minerals, red tiles, and purple Welsh slates, the variegated hues of the marbles of Sicily, Spain, Siena, and Rosso antico, with the exquisite transitions of tint in the pebbles of Scotland and the Rhine. We have all heard of "porphyry" as among the most precious of the harder massive stones. The colour which gave it that noble name, as well as that which gives the flush to all the rosy granite of Egypt—yes, and to the rosiest summits of the Alps themselves—is still owing to the same substance—your humble *oxide of iron*.

In reference to ironwork and artificial colouring generally, the following principles are laid down, and with quoting these at length we must close our notice, as Mr. Ruskin does his book.

"The difficulty of colouring ironwork rightly, and the necessity of doing it in some way or other, have been the principal reasons for my never having entered heartily into this subject; for all the ironwork I have ever seen look beautiful was rusty, and rusty iron will not answer modern purposes. Nevertheless it may be painted; but it needs some one to do it who knows what painting means, and few of us do—certainly none, as yet, of our restorers of decoration or writers on colour. It is a marvellous thing to me that book after book should appear on this last subject, without apparently the slightest consciousness on the part of the writers that the first necessity of beauty in colour is gradation, as the first necessity of beauty in line is curvature,—or that the second necessity in colour is mystery or subtlety, as the second necessity in line is softness. Colour ungradated is wholly valueless; colour unmysterious is wholly barbarous. Unless it loses itself and melts away towards other colours, as a true line loses itself and melts away towards other lines, colour has no proper existence, in the noble sense of the word.

* * * * *

"The skill with which the thirteenth century illuminators in books, and the Indians in shawls and carpets, use the minutest atoms of colour to gradate other colours, and confuse the eye, is the first secret in their gift of splendour: associated, however, with so many other artifices which are quite instinctive and unteachable, that it is of little use to dwell upon them. Delicacy of organization in the designer given, you will soon have all, and without it, nothing. However, not to close my book with desponding words, let me set down, as many of us like such things, five Laws to which there is no exception whatever, and which, if they can enable no one to produce good colour, are at least, as far as they reach, accurately condemnatory of bad colour.

"1. All good colour is gradated. A blush rose (or, better still, a blush itself,) is the type of rightness in arrangement of pure hue.

"2. All harmonies of colour depend for their vitality on the action and helpful operation of every particle of colour they contain.

"3. The final particles of colour necessary to the completeness of a colour harmony are always infinitely small; either laid by immeasurably subtle touches of the pencil, or produced by portions of the colouring substance, however distributed, which are so absolutely small as to become at the intended distance infinitely so to the eye.

"4. No colour harmony is of high order unless it involves indescribable tints. It is the best possible sign of a colour when nobody who sees it knows what to call it, or how to give an idea of it to anyone else. Even among simple hues the most valuable are those which cannot be defined;

Digitized by Google

the most precious purples will look brown beside pure purple, and purple beside pure brown; and the most precious greens will be called blue if seen beside pure green, and green if seen beside pure blue.

"5. The finer the eye for colour, the less it will require to gratify it intensely. But that little must be supremely good and pure, as the finest notes of a great singer, which are so near to silence. And a great colourist will make even the absence of colour lovely, as the fading of the perfect voice makes silence sacred."

Sketch of the Civil Engineering of North America. By DAVID STEVENSON, F.R.S.E., M. Inst. C.E. Second Edition.—London: John Weale. 1859.

A second edition of this useful and well known little work has just been issued. It is stated that the application of the engineering examples which it contains to new countries, and particularly to India, has induced its re-issue. The work may be regarded in a more general view than its title would imply, and might with propriety be called a "Sketch of Engineering Practice applicable to New Countries." Its perusal will be particularly useful to young engineers. The following remarks are made relative to the present condition of the profession in North America, where, with the exception of lighthouse engineering, there seems to have been but little progress made during the last twenty years:—

"Although public works in America have since my visit (1837) been enormously extended, the principles of engineering construction, with slight modifications, remain the same. Labour in the United States is still expensive, timber is still plentiful, and lines of communication have yet to be formed at as small a cost as possible through almost unexplored regions. So long then as engineering practice has, from the necessities of the case, to be adapted to such circumstances, no very great or radical change in mechanical construction, or in management, is likely to be introduced. It is no doubt true that individual works of great extent, and perhaps originality, may from time to time be erected, such, for example, as the bridge across the Niagara connecting the United States with Canada, which is a recent triumph of American engineering, or the bridge across the St. Lawrence on the line of the Grand Trunk Railway, which will be another exponent of the engineering skill of the British, but these may be regarded as exceptional works. They are proofs of engineering skill applied to overcome special difficulties, but they do not alter what may be regarded as the characteristics or peculiarities of American engineering, a sketch of which was all that my treatise was ever intended to give. The works alluded to are not indeed specimens of what may be termed *indigenous* American engineering, or, in other words, designs applicable to a country in its infancy, but rather examples of the engineering of an older school for the first time applied in America.

"In proof of my statement as to the unaltered condition of American engineering practice, I shall refer to one class of works which has been more extended in America during the last twenty years than in any other country, and in which there has consequently been greater scope for improvement—I mean railways. When I visited the United States in 1837, there were 1600 miles of railway open for traffic, and 2800 in the course of construction. In 1856 there were upwards of 26,000 miles of railway in full operation. Now, it is a singular and significant fact, that notwithstanding the formation of so many new lines, and the experience that must have been gained during their construction, the American railway system, if we except its enormous extension, appears to have undergone little or no change during the last twenty years. In the interesting and valuable report by Captain Galton, R.E., made to the Board of Trade in 1857, the same features which I found to be peculiar to American railways in 1837 seem to be regarded as their peculiarities still; showing that there is in the people a *conservative* principle, if we may so express it, which leads them to cling to what they fancy best best suited to their people and climate. We find, for example, in Captain Galton's enumeration of American engineering peculiarities, detailed descriptions of the locomotives with their long connecting rods suitable for steep gradients, and their four-wheeled trucks moving on a centre pivot to enable them to pass quick curves, which were the distinguishing characteristics of American locomotives in 1837; while the cage for catching sparks still occupies the top of the funnel, and the guard or 'cow-catcher,' for warding off stray cattle, runs in front of the engine. The passenger 'cars,' as they are called, are still the same long-bodied carriages, resting on four-wheeled trucks at either end, with seats at either side, and a passage down the centre. The railways in the neighbourhood of towns are as imperfectly fenced as ever, and a large bell on the engine is still rung at the level crossings, which are generally without gates or gate-keepers, while the rails are in some cases still carried to the station through the principal streets, 'the public being,' as Captain Galton expresses it, 'left to take care of themselves.'

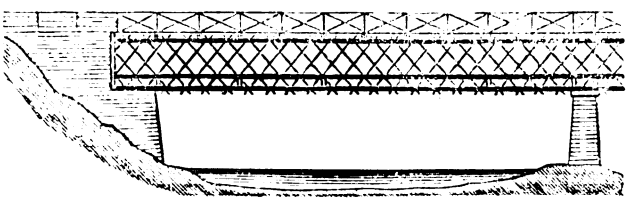
"Nor have I been able to discover that any material progress has been made in the harbour, river, or canal engineering. The fact, indeed, of the rapid extension of railways to which I referred renders it, I should say, impossible that canal and river engineering should receive the same attention which it did in that country previous to the introduction of the new system of communication. I must advert to one exception—the lighthouse system—which was most imperfect when I visited the country, but has since been remodelled."

At page 142 a description is given of "*Town's Patent Lattice Bridge*," which we quote.

"This construction is much employed on the American railways, and is sometimes used for bridges of so large a span as 150 feet: it exerts no lateral thrust tending to overturn the piers on which it rests. A small quantity of materials of very small scantling, arranged in the manner shown in the figure, possesses a great degree of strength and rigidity. For this drawing I am indebted to Mr. Robinson, of Philadelphia, who is constructing many large bridges on this principle on the Philadelphia and Reading railway, several of which I examined both in their finished and unfinished state.

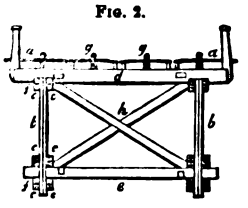
"Fig. 1 is an elevation, and Fig. 2 is a cross section on an enlarged scale of the framework of the bridge, in which *a* is the surface of the railway; the lattice framing or ribs *b*, of which the

FIG. 1.



bridge is formed are composed entirely of pine planks, measuring 12 inches in breadth and 3 inches in thickness. The planks are arranged at right angles to each other, so as to form a fabric resembling lattice-work, as shown in the drawing; and from this circumstance the bridge derives its name. They are fixed at the points of their intersection by oak treenails, 1 inch and a half in diameter, passing through them. The horizontal runners *c*, are formed of planks of the same scantling, and extend throughout the whole length of the bridge. They are also fixed at the points where they intersect the planks *b*, by oak treenails passing through the whole, as shown by the dotted lines at *f*, in Fig. 2. The depth of the lattice-work is proportioned to the span of the bridge. The span shown in the drawing is 78 feet, and the depth of the ribs is 9 ft. 6 in. In a bridge of larger span, the planks *b* would be made of greater length, and another square or diamond added to the lattice-work.

FIG. 2.



"There were only two ribs or frames of lattice-work in all of the bridges constructed on this principle which I examined. One of these was placed under each side of the roadway, as shown in the cross section, Fig. 2, by the letters *bb*. The ribs are connected together at the bottom by cross beams *e*, at every 12 feet. At the top they are connected in a similar manner by beams *d*, at every 6 feet. On these, the longitudinal beams *g* are supported, to which the planking of the roadway is spiked. To prevent the ribs from twisting or warping, they are braced at every 12 feet by diagonal beams arranged in vertical planes, as shown at *h* in Fig. 2. Directly under the roadway, diagonal braces arranged in horizontal planes are introduced to render the structure rigid, and braces are introduced connecting the lower part of the lattice-frames. The diagonal braces are all fixed in the same manner. One of the extremities rests in a seat cut for it in the beam against which it abuts, and wedges of hard wood

Digitized by Google

are inserted at the other end, by which the brace can be nicely adjusted, and afterwards tightened up, should the vibration of passing trains, or the effects of the atmosphere, cause any yielding of the timber to take place.

"The lattice-frames have a rest of about 5 feet in checks formed in the stone abutments for their reception, as shown in the elevation given, Figure 1. If the bridge is of greater extent than can be included in one span, it is simply rested on a thin pier, in the manner shown in the elevation, without any other support. A covering of light boarding, extending from the level of the roadway to the bottom of the ribs, is spiked on the outside of the lattice-work to preserve the timber."

LIGHTING PUBLIC GALLERIES BY GAS.

THE commission, consisting of Professors Faraday, Hofmann, and Tyndall, Mr. R. Redgrave, R.A., and Captain Fowke, R.E., —appointed for the purpose of reporting to the Lords of the Committee of Privy Council on Education "On the Lighting of Picture Galleries by Gas, and on any precautions (if necessary) against the escape of Gas, and the products of its combustion," —having met at various times and considered the subject referred to them, now make the following report.

There is nothing innate in coal gas which renders its application to the illumination of picture galleries objectionable. Its light, though not so white as that of the sun, is equally harmless; its radiant heat may be rendered innocuous by placing a sufficient distance between the gas jets and the pictures, while the heat of combustion may be rendered eminently serviceable in promoting ventilation.

Coal gas may be free from sulphuretted hydrogen compounds, and in London is so at the present time; it then has little or no direct action on pictures. But it has not as yet been cleansed from sulphide of carbon, which, on combustion, yields sulphurous acid gas capable of producing 22½ grains of sulphuric acid per 100 cubic feet of present London coal gas.* It is not safe to permit this product of the combustion to come in contact with pictures, painted either in oil or water colours; and the commission are emphatically of opinion that in every system of permanent gas lighting for picture or sculpture galleries, provision should be made for the effectual exclusion or withdrawal of the products of combustion from the chambers containing the works of art.

The commission have examined the Sheepshanks' Gallery as an experimental attempt to light pictures with gas, and are of opinion that the process there carried out fulfils the condition of effectually illuminating the pictures, and at the same time removing the products of combustion. According to the indications of the thermometer required and obtained, it does this in harmony with, and in aid of, the ventilation, and does not make a difference of more than one degree Fahrenheit at the parts where the pictures are placed, between the temperatures before and after the gas is lighted.

Certain colour tests, consisting of surfaces covered with white lead or with vegetable and mineral colours (especially the more fugitive ones), and in which also boiled linseed oil, magylp, and copal varnish were employed as vehicles, had been prepared, and were, when dry, covered one fourth with mastic varnish, one fourth with glass, one fourth both mastic varnish and glass, and one fourth left uncovered. Sixteen of these have been placed for nearly two years in different situations, in some of which gas has been used, in others not. They give no indications respecting the action of coal gas (except injury from heat in one placed purposely very near to and above the gas burners), but seven of them show signs of chemical change in the whites, due to either a town atmosphere or want of ventilation. The most injured is that from the National Gallery, Charing-cross, and the next is from a country privy; the third much less changed is from the House of Commons; the fourth is from the Barber Surgeons' Hall; the fifth from the Bridgewater Gallery; the sixth from the Royal Society's Rooms, Burlington House; the seventh from the British Museum. The remaining tests hung in—

1. Sheepshanks' Gallery, South Kensington;
2. Secretary's room at South Kensington, where no gas is used;
3. Mr. Henry Drummond's drawing-room at Albury Park, Surrey;
4. Sealed up and kept in a closet in the secretary's room at South Kensington;
5. Lambeth Palace, vestibule of the staircase;
6. British Institution, Picture Gallery;
7. Windsor Castle, room with a north aspect without gas;
8. Mr. Thomas Baring's Picture Gallery, 41 Upper Grosvenor-street, frequently lit with gas,

—present no observable change in this respect.

Though apart from the especial subject submitted to the commission, the members cannot resist a recommendation that this kind of trial, which is especially a painter's experiment, should be continued for a longer period, and, indeed, be carried out on a more extensive scale.

The commission think it right to state that they were unanimous on all the points to which their attention had been called, or which are referred to in this Report.

* Hofmann.

CLARK'S PATENT PROCESS FOR RAISING SHIPS.

AN experiment was made at the Victoria Docks on the 27th ult. to test Mr. E. Clarke's patent process for raising ships by hydraulic pressure, for the purpose of examination and repair. A floating stage or pontoon is placed in a basin or water way, and the vessel is floated upon it, and by hydraulic pumps the stage, with the vessel upon it, is raised. The hydraulic lift consists of two parallel rows of 16 cast-iron columns, each 5 feet diameter, and 60 feet long, sunk into the ground about 12 feet. These columns are 20 feet apart in each row, the space between the two rows is 60 feet. Each column contains an hydraulic press of 10 inches in diameter and of 25 feet stroke. The ram of each press carries a small cross-head, from which are suspended by descending rods two wrought-iron girders 60 feet long, extending across the dock to the corresponding column and press on the opposite side. There is thus a series of 32 suspended girders extending across the dock; and when the presses are lowered, lying at the bottom of the dock in 28 feet of water, these form a large gridiron, which by the presses may, with a vessel upon it, be raised out of the water or lowered at pleasure. The vessel is not raised directly upon the gridiron, but upon an iron pontoon. This pontoon is first placed upon the gridiron, and sunk with it in the water. Then the ship is brought between the columns and over the pontoon, and a 50-horse engine working the hydraulic presses raises the whole pontoon together. At this stage the pontoon empties itself of water through valves, which are then closed, and the gridiron being again lowered to the bottom, the pontoon, with the vessel seated upon it, is left afloat on the surface. In less than 40 minutes a vessel drawing 18 or 20 feet of water is thus left afloat on a shallow pontoon drawing only 4 or 5 feet. At the Victoria Docks the lift consists of 16 columns, which give a working length of more than 340 feet. The experiment was considered very successful. The vessel experimented upon was of 1200 tons burden.

BREAKWATERS.

(*With an Engraving.*)

AN answer to certain portions of the Royal Commissioners' Supplementary Report on Harbours of Refuge, recently issued, has just been published by Mr. Abernethy, of Parliament-street, Westminster, who is engineer-in-chief of extensive dock and harbour works contemplated and at present in progress in different parts of the kingdom, and who was examined before the commissioners at great length on the present and projected modes of constructing breakwaters. Considering as we do that the question is a very important one for the country, inasmuch as the systems at present adopted entail an enormous outlay both of time and money, we give at some length Mr. Abernethy's views on the subject, which he maintains have not been controverted by the reasons assigned in the commissioners' report for their non-adoption. On these he comments at length, and ends by stating,—

"I have thus commented on all the reasons for objecting to my local design contained in the report of the commissioners, and of their weight and value I now leave others to judge. I remain convinced that the present long slope or random rubble mound system, with a vertical superstructure, is unscientific, and incurs an unnecessary expenditure of time and money, when applied to any site having even an ordinary rise and fall of tide. I learn it may be applied to a site in the neighbourhood of the Cape of Good Hope, exposed to the long swell of the Indian Ocean; if so I think the colonists, if they provide the necessary funds, deserve sympathy; on the other hand, if they are to be provided by the parent country, it is desirable the House of Commons should, in

Digitized by Google

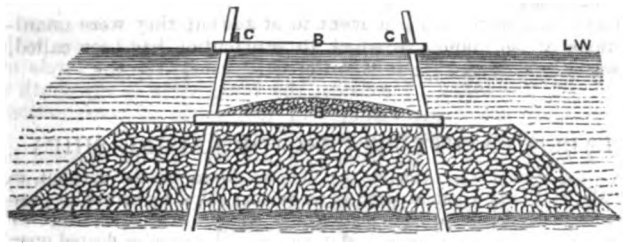
the first place, cause a more careful investigation to be made into the whole subject of construction, as applied to the formation of breakwaters."

He has appended to his pamphlet a design for a breakwater at the Mumbles Roadstead in the Bristol Channel, relative to which he furnished the Royal Commissioners with the following statement:—

Mode of Construction.

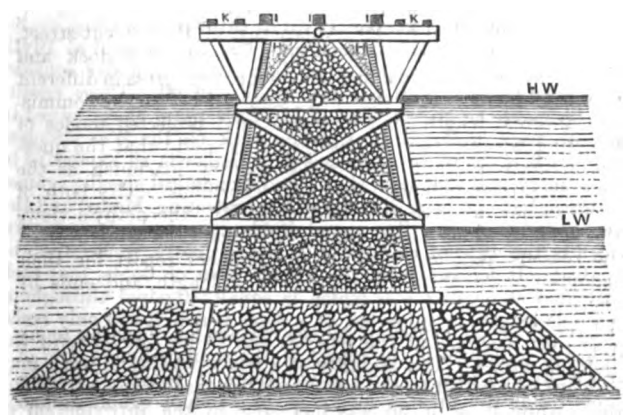
"First.—Piles, two in number, AA (Fig. 1), are driven to a depth of 10 feet or thereabout below the bed of the sea, the top of the piles being 5 feet above the level of low water; these are to

Fig. 1.



be connected together transversely by tie pieces BB, four in number on each side of the piles, to which they are to be bolted by screwed bolts. In the line of the proposed breakwater, and 10 feet from the centre of these piles, similar piles are to be driven, and connected in the same manner, the various sets of piles being connected longitudinally by inner wales, CC. A certain continuous length of these sets of piles being driven, a mound of rubble stone, or pierre perdu, is deposited within and around the piles, as shown by Fig. 1, the top of this mound being 15 feet below the level of low-water spring tides. A certain continuous length of these piles and rubble mound being completed, a timber framework D (Fig. 2), previously framed and constructed on shore, is lowered down over the top of the piles, and bolted and secured to the ends of the cross ties BB, similar frames being lowered over the adjacent sets of piles, and the whole connected longitudinally by wale pieces EE (Fig. 2). A certain length of these frames being thus fixed in their places, balks of timber 12 in. by 6 in. and 6 in. apart, or panels framed together, are bolted on behind the piles up to the level of low-water FF (Fig. 2), and the space within these panels may be then filled in, to a certain extent, with dry rubble stone packing; an additional framework G, is then constructed within and above the previous framework, the uprights of which are to be securely bolted to the cross and diagonal ties, the foot of the uprights resting on the top or head of the lower piles, which are cut off to the level of low-water mark. A certain length of these frames being constructed, and further connected longitudinally by additional wale pieces HH, (Fig. 2,) half balks of timber 6 inches

Fig. 2.



apart are bolted on to the inner side of both sides of the framework, and carried up *pari passu* as the rubble filling progresses. The rubble being tipped from waggons from the top of the framework, or filled in from barges, as circumstances may render expedient.

"Lastly. The framework being completed, and its interior packed with rubble, as shown by Fig. 2, timber bearers and rails for carrying powerful hydraulic cranes I, I, I, are to be laid on the top of the framework with outside bearers for two roadways KK, for lines of railway to carry the stone trucks; these may be dispensed with in certain cases, the stones or masses of masonry being brought alongside the breakwater in lighters, and deposited *in situ* by the hydraulic cranes. Thus will be formed a loaded timber breakwater, possessing a continuity of structure, in addition to its weight or inertia, which renders the breaching of any of its parts by the action of the sea extremely improbable, and the timber of which it is composed, being thoroughly creosoted under pressure, which renders it, from my experience, impervious to the ravages of the worm, it may reasonably be expected to last a long period of time. The design here shown I propose to apply to sites such as the Mumbles Roadstead in the Bristol Channel, or Hartlepool Bay, where it is assumed that the nature of the ground for foundation is of a character that renders any material subsidence of the rubble masonry at least improbable; but even supposing a subsidence did take place to such an extent as to injure the cross ties in certain cases, it would not affect the stability of the structure; the first and principal object of these ties being to fix and secure in their places the piles AA, (Fig. 1), previous to and during the disposition of the rubble mound. In ground of a nature which renders subsidence probable, the rubble mound may be allowed to consolidate for a given period of time, and the details in the arrangement of the timber work can be arranged to meet such a contingency.

Rate of Progress.

"The general arrangement to be observed in the construction of such a work, and its rate of progress, selecting as an example the Mumbles or Hartlepool Bay as sites, and dealing with the loaded timber breakwater as the nucleus or means of forming a permanent structure of masonry of an enduring character, I should propose to be as follows:—

"1st, To provide all the necessary creosoted timber, and to build for the facework large and uniform masses of masonry on shore, allowing sufficient time for these to become hard and compact before being deposited in the work. These masses of masonry to be not less than 20 tons weight, ranging to 30, or even more; and composed, in the case of the Mumbles, of the hard sandstone of the coal measures, set in best hydraulic mortar; at Hartlepool, substituting the magnesian limestone, for the foundation courses up to the level of 6 feet below low-water level; for the superstructure from that level, to the height of 10 feet above high water, I should construct similar masses of rubble masonry, faced with hard stone ashlar, toothed or bonded into the rubble.

"A sufficient quantity of material being thus prepared, which I presume would occupy a period of twelve months, I should proceed during the last half of this period to drive the lower piles for a continuous length of 1500 feet or thereabout, and to form the rubble mound, which I estimate could be executed in a period of six months.

"In the formation of this mound at the Mumbles I should use copper slag for its outer portion, beyond the toe of the facework; using the mountain limestone for the interior. The slag being heavy and angular would be less liable to disturbance, and like most vitrified substances it is very durable; moreover, its great specific gravity would tend to prevent any lateral spreading of the central mass of limestone, and cause any subsidence to be in a vertical direction.

"After a portion of the mound had been deposited for a period of three months, I should proceed to form the framework, completing it at the rate of 500 feet in three months; and as soon as the first 500 feet of this work was constructed, I should proceed with the face masonry at the same rate, observing as a rule, four stages of the work *pari passu* with each other:—1st, the masonry in progress; 2nd, the timber breakwater formed: 3rd, the same in progress; 4th, the formation of the rubble mound.

"The whole time occupied in the construction of such a work as that proposed at the Mumbles, a total length of 6600 feet of breakwater, would be as follows;—1st, preparation of material, say 12 months; 2nd, construction at the rate of 500 feet in three months, being a total period of four years and a half or thereabouts.

"I propose to lay the facework in alternate courses of headers and stretchers, connected together by cast-iron dowels, and cemented above low-water level with the best hydraulic mortar. As the masonry proceeds, a certain portion of the timber only is proposed to be inclosed or absorbed within it.

Digitized by Google

Timber and Rubble Stone Structure treated as a Breakwater, &c.

"In this description I have treated the loaded timber breakwater in connection with the stone structure, but it may be used as a breakwater *per se*, for a long time. Taken in connection with the stone structure it affords a firm basis for setting great masses of masonry, which, from their weight and abutment on the timber framework within, cannot be breached by the action of the sea; thus enabling the work to be carried on with safety in sections of considerable length, instead of being carried on, as in the case of existing works in progress, from the end merely. The loaded timber breakwater affording, moreover, in a very short period of time, a considerable amount of shelter. Structures of such a character might be applied as an economical and effective protective work for ports possessing but limited financial resources.

"The great cost generally of stone piers, and their liability to breaching by the action of the sea, more particularly during progress of construction, is well known, and has been felt by every engineer practically conversant with marine works; and I am aware that these causes have rendered, in a great measure, nugatory the means at the disposal of the authorities of various harbours on the coast of the United Kingdom, especially on the east coast of Scotland; so that, as a general rule, the works actually executed are limited in extent, and inadequate for the protection and safety of the shipping. If a mode of construction had been followed, comparatively safe and economical, in the first instance, works of greater magnitude might eventually have been carried out, from results of the additional revenue thus afforded; whereas, in many instances, the attempts at harbour improvement, to meet the demands and encourage the growth of trade, have only ended in disappointment and financial difficulty."

Comparison with present Works and Modes of Construction.

"I now proceed to compare the proposed system of constructing breakwaters with that followed at existing works, selecting the case of the breakwater at Holyhead as an example.

"A careful consideration of the two systems leads me to the following conclusions:—1st. That the proposed new method admits of more rapid completion, and is less liable to risk during progress of construction. 2nd. That a considerable saving is effected in the quantity of material used, and, consequently, in cost of construction. 3rd. That great durability is insured, arising from general form and the nature or quality of the material.

"With regard to the first of these.—By the present system the rate of progress is defined by the number of waggons which can be discharged from the termination of a given number of roads; and in the case of Holyhead, the proportion between the required rubble mound and that now proposed being as five to one, it is manifest that a much greater length of time must be required to form it; while the superstructure cannot be carried on *pari passu* with the formation of the embankment or mound, as in the latter case.

"Moreover, the timber staging at present in use is constantly liable to be carried away in storms, whereas the staging proposed being connected together as a continuous work, and loaded with a mass of rubble, is independent of its use as a breakwater, *per se* of greater strength, and more capable of resisting the action of the sea.

"As regards the saving in material and cost, the estimated quantities in one lineal yard of a breakwater on the Holyhead system applied to the Mumbles site, as compared with the proposed structure, is as follows, excluding the parapet in both cases:—

Holyhead.			Proposed system.	
Cubic yards	2472	Rubble stone	500	
Cubic feet	1201	Ashlar facework	1118	
Cubic yards	48	Rubble backing in mortar	94	
Cubic feet	396	Pitching	219	

"As regards the cost of each, as I have not the means of instituting any other comparison, I have simply computed the quantities of material required in each case, applying the same scale of prices. And I find the result as follows, in the case of the proposed Mumbles breakwater:—By the Holyhead system, £1,742,620; by the proposed system, £895,400. I believe this is a comparison in favour of the former, because the risk and cost of such a mode of construction, on a site subject to a great rise and fall of tide, is increased by the exposure of the staging, and the long slope of the rubble mound, to the prolonged and violent action of the sea. To these must be added the difficulty of transporting under these circumstances to the site a vast quantity of material.

"With regard to durability, I have to remark, that the system of depositing a rubble mound up to the level of high-water mark as a basis for a solid and vertical superstructure of masonry, has always appeared to me a costly and injudicious mode of construction in deep water, as the long slope, thus necessarily formed seaward, converts the undulating ocean wave into the shoal water, progressive, or percussive breaker, and the consequence is a violent disturbance on the seaward face of the rubble mass, which, by the constant action of the sea, must ultimately be reduced to a mass of boulder stones, while the vertical portion is subjected to incessant percussive action. In the case of Holyhead, I am convinced, that for the preservation of the superstructure, it will ultimately be found necessary to pitch the outer slope with massive ashlar, at a great expense, at least between the levels of high and low water. I consider the breakwater at Plymouth a much more consistent example of this mode of construction, denuded as it is of any vertical superstructure.

"A breakwater of the form proposed will not be exposed in any material degree to the action of a percussive force, but merely to what may be termed the hydraulic action arising from the rise and fall of the undulating deep-water wave.

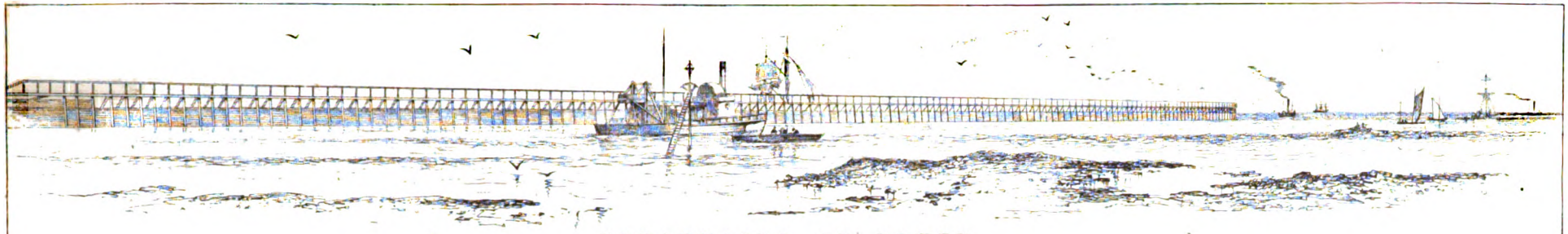
"In conclusion I have to express my firm conviction that, by means of powerful staging and machinery capable of depositing with rapidity and ease large masses of masonry, breakwaters with vertical face walls carried up even from the bed of the ocean, may be executed in a much shorter period of time, and at considerably less cost than has hitherto been attained.

"The practicability of meeting these requirements admits of no doubt. As regards the necessary machinery and power to deposit masses of great magnitude, my practical experience of the facilities afforded by the application of hydraulic power, in various and numerous forms and appliances by Mr. Armstrong, of Newcastle, convinces me that as regards labour, time, or facility, a mass of twenty tons may be deposited at the same cost as a stone one-tenth part of that weight by the ordinary means in use. For sites exposed to the action of the Atlantic or ocean wave, or where it is not expedient to form a base mound of rubble stone, I bring up the face walls from the bed of the sea in a depth of seven fathoms.

"I apply what I term the vertical system to deep water breakwaters; in shoal water, and under certain circumstances, the long slope system, I am aware, from experience, may be applied with advantage."

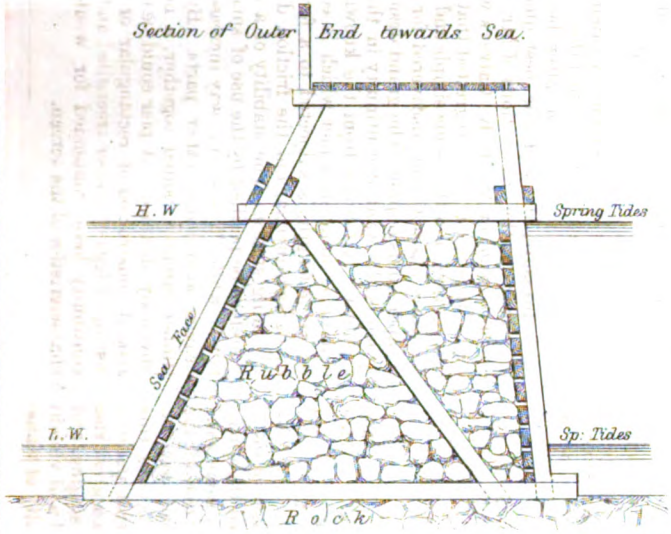
Mr. Abernethy has completed a pier or breakwater at Blyth, in Northumberland, on this principle, (see Plate 21) 5000 feet in length, at a cost of £35,000, which fully answers its purpose, having been exposed to the action of heavy seas without sustaining the slightest damage, while the creosoted timber of which it is in part composed has proved impregnable to the ravages of the worm so destructive to unprepared timber on that part of the coast; portions of unprepared timber, placed in the structure for experiment, were completely eaten through to a considerable depth in a period of twelve months. The timber used at Blyth was creosoted on the spot, after being framed, under considerable pressure, and with the best quality of oil. These results fully bear out the observations of Mr. Stevenson, as contained in the 56th page of Mr. E. K. Calver's work on the Wave Screen, viz., "It is much to be regretted that timber is so expensive in this country, and that some simple and economical specific against the worm has not been discovered for protecting Memel and the cheaper kinds of pine. The grand desideratum in harbour works, which is the want of continuity in the structure, would then be supplied. It follows, from the known laws of fluids, that each individual stone in a pier which is equally exposed throughout its whole length, is subjected to a force which it can only resist by its own inertia, and the friction due to its contact with the adjoining stones. The stability of a whole hydraulic work may therefore be perilled by the use of small stones in one part of the fabric, while it is in no way increased by the introduction of heavier stones into other parts. By the use of long logs of timber carefully bolted together, a new element of strength is obviously obtained. A pier could be executed almost free of sea-risk, if constructed of rectangular or other shaped prisms, consisting of logs of timber treenailed and bolted together, &c." The continuity here contended for would be one of the marked characteristics of the screen.

Digitized by Google

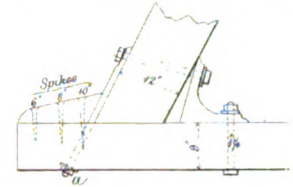


BREAKWATER AT BLYTH.

Section of Outer End towards Sea.



Elevation of fastenings at A.

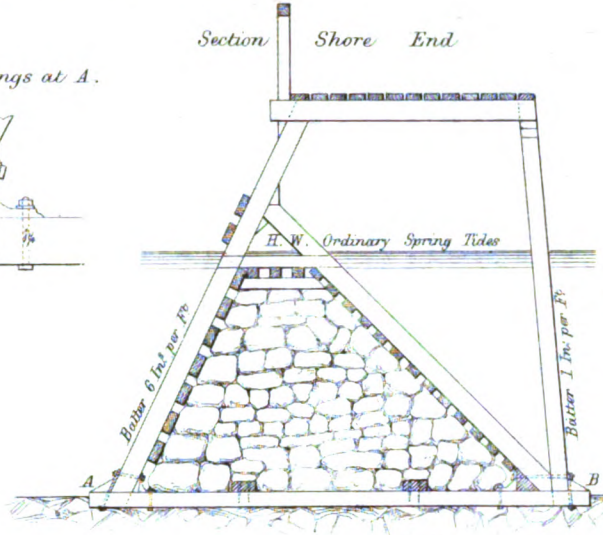


Bolt a

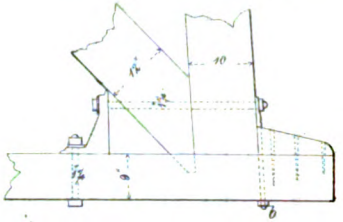
Plan



Section Shore End

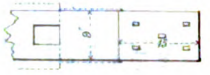


Elevation of fastenings at B.



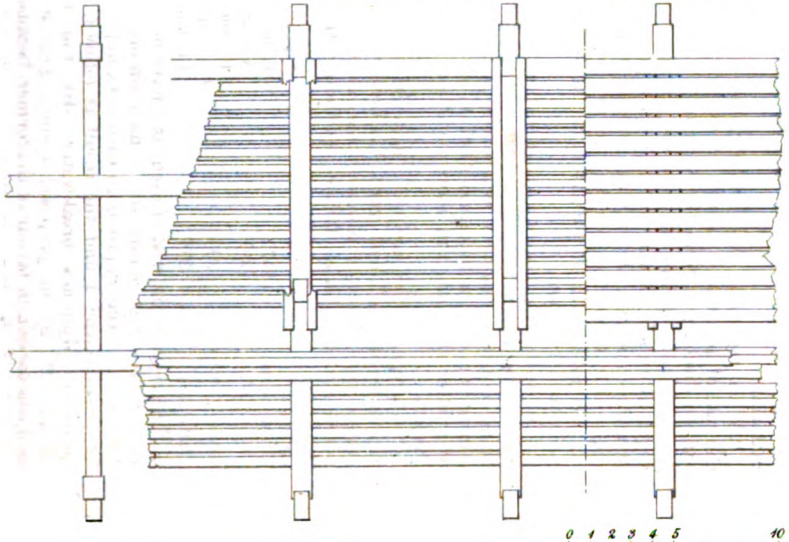
Bolt b

Plan



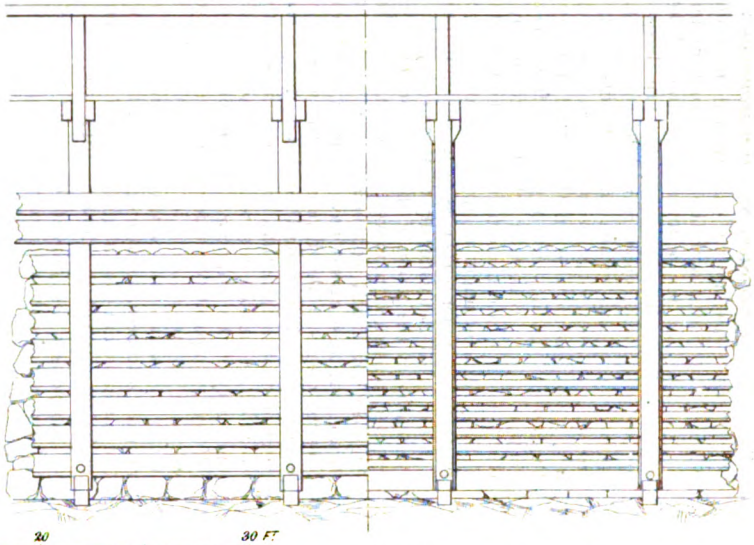
Plan

Below Platform Above Platform



Elevation

Seaward Face Channel Face



0 1 2 3 4 5 10 20 30 FT

August 1859

J.R.Jobbins

Digitized by Google

Digitized by Google

ON THE ARCHITECTURE AND GENIUS OF SIR CHRISTOPHER WREN.*

By G. WIGHTWICK.

THE native sovereignty of genius was, perhaps, never despotically independent of the circumstances attending its birth and earliest development; and when we read that the infant energies of a boy's mind were industriously directed by a father "of great scientific knowledge and of extensive attainments in literature and mathematics, with considerable skill in the noble art of architecture," we are not to wonder that "tractable precocity" should resign itself to that particular lead whose results constitute the popular monument of its fame; but which, after all, are no greater testimonials of power and accomplishment than other evidences confined to the appreciation of the few.

Under such circumstances was manifested the genius of "that miracle of a youth," Christopher Wren, who, in his twenty-third year, was recognised by Evelyn as "a rare prodigy of universal science." The pre-eminent distinction of his mind, however, was not its capacity for receiving knowledge, but its application in augmenting the stores of science, and still more particularly its inventive power in the constant produce of the most useful novelties. The creative, in short, as the most essential attribute of genius, was Wren's in a marvellous degree; and, in respect to the universality of his attainments and powers, it may be emphatically remarked, that had he never been known as an architect he would have been by so much the more known as a man of scholastic literature, philosophy, and science. Before he comes before us as an architect, he brings the highest credentials from the classic professors of Isis, the mathematicians of Cam, the astronomers, chemists, and scientific members of the Royal Society, and from the mechanic in all his then known means of operation.

All that Vitruvius requires of an architect was Wren's, without any especial architectural intent; but as Mr. Cunningham observes, "his mathematical acquirements gave him extensive command over the very principles out of which true architecture arises." Perhaps we should rather say, he found in his mathematical erudition the chief (or one of the chief) of its principles; for in the varieties of physical science lie others also of great suggestiveness, and the architecture of Wren arose out of his varied knowledge—his knowledge of all things necessary to its development, as the issue not more of geometrical beauty than of material science and constructive perfection. In short, the genius of Wren had induced the acquirement of every accomplishment as an operative builder, before he was called upon to cultivate the artist. He had inherited from his father a peculiar feeling for architecture as a fine art, though for many years it had occasioned little more than the external observation by which he had naturally imbibed an ever-increasing sense of the beautiful, awaiting only the occasion for his analysis of its just principles; and when the occasion came, a comparatively brief appliance of his acute perception, acquisitional capability, and thoroughly informed invention, was necessary to the result finally exhibited in the august amplitude of St. Paul's cathedral.

And whence came his ability as an artist? Certainly not from academical or official instruction, for until the age of twenty-nine, when he was suddenly called upon to assist Sir J. Denham as Assistant Surveyor General, we hear nothing of him even as an architectural amateur. So immediate, however, was the manifestation of his ability as a practical architect, that at the age of thirty-one he erected his first building, the Sheldon Theatre, at Oxford. The truth is, he was at that time, more than any other man in the kingdom, equal to anything of national importance that might be required; being indeed the "admirable Crichton" of mind in its all-applicable power and comprehensive acquirements. The leading mathematicians of Europe had visited England to see the famous Wren; a distinguished classic had spoken of his poetical accomplishments as raising him even above Ben Jonson as a translator of Horace: and when Newton was a tyro, Wren, with Boyle and Hooke, was opening the way for the former with "the greatest contributions to science ever yet produced." The love for architecture, therefore, was only a part of his sympathy for everything that could address a man of genius; and had there been no mathematician of eminence besides himself, nor any remarkable poet, painter, sculptor, astronomer, chemist, optician, or mechanic, Wren would have been all or any of these, as the necessity of the time might have required; but Inigo Jones was dead, and there was no architect. Who, then, could be called upon when the great fire of London had left the city with no architecture? Who, save Wren? He had not, like Jones, visited Italy to study its ancient and Palladian buildings, though he did make "a trip to Paris," where he thought he saw inimitable things, unconscious, in his modesty, how greatly he was to surpass them. He read his Vitruvius; speedily gathered what knowledge was available, immediately anticipating the results which come to others by slow degrees; and in three years from his first operations as an amateur architect, he had "concentrated all his powers on his new study, to the diversion of his mind from its former pursuits." The true character of his genius as an architect is strikingly shown in his having adopted no mannerism from his teachers, or from the examples that had addressed him. Having mastered with readiest facility all the details of Classic design, he obeyed the sole promptings of his native imagination, fancy, and independent (though educated) taste, in the production of models which, to reverse his own expression, "Bernini might have been willing to give his skin for;" though, of course, we now allude to the greater and more select examples on which his fame is grounded.

And now, in the estimate of his genius as an architect, we may begin by referring to his very qualified regard for our Mediæval examples. It is to be presumed he looked upon our Anglo-Norman churches as little better than picturesque, but clumsy, free imitations of the Roman method; and we know that he viewed their pointed successors as a compound of the same with the "Saracenic." "Gothicism" with Wren meant barbaricism. The barbaric splendour of our old cathedrals he admitted, but, in his report on old St. Paul's, he speaks of the "carelessness and want of accuracy in its builders"—of the "good Roman manner," as opposed to "Gothic rudeness"—of "the lean shaft" of the old "steeple:" and calls his design for the new St. Paul's, as executed, "the Gothic rectified to a better manner of architecture." But though Gothic design seems at that time to have been almost ignored, as unworthy the name of architecture, Wren was not insensible to the magnificence of the cathedral of Salisbury, which, he says, by a venerable kind of grandeur, strikes the spectator with a sacred joy;" and which he commends beyond divers Gothic buildings of later date; while in his surveys of that edifice and of Westminster Abbey, he manifests a marked sense of much that was due to the Mediæval builders.

It must however be admitted, that Wren was influenced by the general distaste of his day for Gothic art, and the question remains, what he would have done had he lived at the time of its revival? It is likely he would have been for systematising Gothic design, and for bringing it into geometric propriety; subjecting it to those laws which should govern all styles, the "complete beauty" of which, to use his own words, "is secured in variety of uniformities."

We may not certainly adduce his Westminster towers as any evidence of what he would have done; but there is a little in the tower of St. Michael's, Cornhill, a little more in the bell tower of Christ Church College, Oxford, and much more than a little in the steeple of St. Dunstan's in the East, to indicate what, under the more propitious circumstances of the present day, Wren might have accomplished as a Gothic revivalist.

The consideration, however, more fairly and assuredly affecting our estimate of Wren's genius as an architect, is that which has reference to the time and circumstances of its operations.

The time prescribed the style to be adopted. The approval awarded to Inigo Jones' application of a Corinthian portico to a Gothic cathedral left it a matter of certainty that the European taste for Classic art had no exception in England. While Wren was being rocked in his cradle, the church of St. Peter at Rome was being completed; and in Paris, the old cathedral of Notre Dame had no more influence than Westminster Abbey in London, to preserve any feeling whatever for Gothic design. The Louvre and the church of the Invalides, in the French capital, arose in obedience to the same common impulse which produced the Whitehall banquetting room and the cathedral of St. Paul in the British metropolis. As we have seen, however, Wren obeyed not the dictation of fashion only, but has left on record his practical reasons for selecting the "Roman manner of building," as most fitted for the permanent glories of architecture. The time, therefore, was rather favourable to the development of his personal ideas than imperative in governing them, and he adopted at once, without any essential change in detail, the style presented

* Paper read at the Royal Institute of British Architects.

Digitized by Google

to him by his immediate predecessors and cotemporaries. The new cathedral was to be, and Wren's genius was at hand that it might be in perfection; subject only to one most injurious impediment, viz., the unhappy meddling of the papist party (then in power), whose leader (the Duke of York) was determinate in the re-employment of the old cathedral form or plan, which grievously militated against the admirable originality of our architect's independent conceptions.

No more than a simple reference is necessary to the plan of Wren for rebuilding London after the fire. It is, of course, chiefly a thing of ingenious and judicious arrangement, reconnecting the severed parts of the city which had escaped destruction; the adoption of which would have been a noble preparation for all the architecture which has since been presented under such lamentable disadvantages.

In contemplating the floor plan of the rejected model of St. Paul's, we immediately see how its author has set at nought the influence of familiar custom as a cause of beauty. We have a general outline and internal disposition of parts perfectly original. Instead of the ordinary rectangular combination, we have the square, the curved, the polygonal, the concave, the convex, the recessed, the salient; affording the most varied play of full light and half light, sharp in contrast with shadow and shade, or softly gradational the one into the other; while the outline of the plan includes within its full bodied expanse the cross as the skeleton form, whose dome-crowned centre is the "heart of the mystery."

In the existing cathedral we see the old Gothic model Romanised, with a dome *vice* a central tower, and instead of flying buttresses openly exhibited, a decorated screen looking like an upper story concealing them; but in the model we have a design not less original than magnificent, with artistic feeling far exceeding what is displayed in any single building of ancient or modern times. The refined *pictorial*, of bulk and varied form, here presents itself in lieu of the Gothic *picturesque*, of attenuated length and transeptal interruption.

And now leaving the outline, let us contemplate the floor plan. Let the reader especially imagine the first long and narrow perspective from the west door; the forthright and divergent views, on his passing the arch next beyond the vestibule; the view on just entering beneath the great cupola; that from the centre of the same; and that from beneath one of the diagonal cupolettas. All this justly considered, he may so conceive of the magical effects realised as to see "with his mind's eye" how comparatively commonplace are the effects produced in the existing cathedral. Well may we believe that its designer wept at the rejection of his model; and well might we weep that it was rejected!

In the model the portion for the choir is of a form much more adapted to the purposes of Protestant worship than in the building, and of a capacity equivalent to what Wren pronounced the maximum size for an auditorium, in which all the sitters may distinctly see and hear the preacher; *i.e.* it is equal to a room 80 feet long and 50 feet broad, exclusive of the space required for the organ and the communion recess. Wren was the last man in the world to design a building without a full regard to its use. He rightly felt, however, that a cathedral is not a mere thing of practical utility; but that it should be the offering of art's best to the Giver of artist genius. In St. James' church, Piccadilly, he considered the matter on mere utilitarian grounds, and even there produced a structure the interior of which remains a monument not more of his scientific economy than of his feeling for the beautiful.

Having commented on Wren's own, we have now to examine St. Paul's Cathedral as it exists; a building whose beauties are equally his own, and whose defects (mainly occasioned by interference) still leave it unequalled as a model by any structure in existence. In its general external mass it exhibits a wondrous combination of majesty and elegance; the expression of amplitude in the cupola of its interior is without equal; and if the architect's doings had found co-operation in the sculptor and painter, the London St. Paul's would have yielded to the Roman St. Peter's only in size.

Under the determined predeliction of Wren's dictators for the old cathedral plan, "his genius was rebuked;" and all he could do was to modify the prescribed form, so as to reconcile, as far as possible, a new body to an old habit. Even in this he was still beset by meddlers; and it was by command of the popish Duke of York that the north and south chapels near the western end were added, to the reduction of the nave aisles, and the lamentable injury of the return fronts of the two towers, which therefore lost in apparent elevation by becoming commingled with pieces of projecting façade on the north and south sides. Thus were produced the only defects in the longitudinal fronts of the church. The independence of the towers is destroyed; their vertical emphasis obliterated; and a pair of excrescences is the consequence, which it were well to cut away. All that could be done to diminish the evil was accomplished; but no informed eye can view the perspective of the cathedral from the north-west or south-west, without seeing how no architect, who only admitted a "variety of uniformities," could have intentionally formed a distinct component in an exterior of otherwise uniform parts, by a tower having only one wing, and that too flush with its face. With this exception the general mass of the cathedral is faultless, *i.e.* as the result of a conciliation between the architect's feeling for the Roman style, and his compelled obedience to the shape prescribed. With this consideration the grand building under notice must be judged. This it is which excuses the application of the upper order as a mere screen to conceal the clerestory and flying buttresses; for it must be admitted that uninterrupted altitude of the bulk in the same plane is absolutely necessary to the substructure of the majestic dome, which is indeed the very crown of England's architectural glory. The four projections which fill out the angles formed by the intersecting lines of the cross finely buttress up the mountain of masonry above; and the beautiful semicircular porticoes of the transepts still further carry out the sentiment of stability.

As to the dome in itself, it stands supreme on earth. The simple stylobate of its tambour; its uninterrupted peristyle, charmingly varied by occasionally solid intervening masonry, so artfully masking the buttress-work as to combine at once an appearance of elegant lightness with the visible means of confident security; all these, with each subsequently ascending feature of the composition, leave us to wonder how criticism can have ever spoken in qualified terms of Wren's artistic proficiency.

The western front must be criticised as illustrating in great measure a Gothic idea Romanised. Instead of twin spires (as at Lichfield) we have two pyramidal piles of Italian detail; instead of the high-pointed gable between, we have the Classic pediment, as lofty as may be; the coupled columns and pilasters answer to the Gothic buttresses; and a minute richness and number of parts, with picturesque breaks in the entablatures (though against the architect's expressed principles) are introduced in compliance with the general aspect and vertical expression of the Gothic façade.

The exception to this is, of course, shown wherever the entablatures continue their unbroken horizontality over insulated columns; as in the great portico of the west front, the porches of the transepts, and the peristyle of the dome. The architect has, however, well achieved the required compromise between two differing modes of design; and, as an harmonious amalgamation of the vertical and horizontal, the west front of St. Paul's is not only a success, but a triumph. The lower extended colonnade, and the upper part of the portico, contracted and pedimented, in their combination pyramidize, so as to prevent any feeling of excess either in height or width; and whether we regard the towers from base to apex as distinct compositions, or as parts of the entire front, we recognise much beauty as well as ingenuity in the manner of their resolving themselves from a pure Roman beginning into a fanciful termination, not unsatisfactory even to the Gothic steeple-lover. There is, however, one aspect under which the entire building would exhibit a perfection scarcely yet contemplated, save by an architect: such an aspect would be presented at about 3 p.m. on a fine, clear, and sunny day, if the complete pyramid of the structure, from the outer steps of the transept porticoes to the ball and cross, could be seen in direct front from Temple Bar. At that distance the western towers, instead of encroaching slightly on the peristyle of the dome, would be detached from it; the transepts would be in an equal degree, but not injuriously, intruded on; while the west front would just gain the apparent increase desirable.

The floor plan of the church requires little comment. It exhibits no invention, for invention was forbidden. Excepting the projecting parts in the outer angles of the cross, where the transepts unite with the nave and choir, it has no arrangement not to be found in our old Gothic cathedrals. Even the absence of the four great piers which usually support a central tower has its Gothic precedent in Ely cathedral, where a lantern overhangs the great central octagon, just as the cupola in St. Paul's.

Digitized by Google

We have, therefore, only to estimate the manner in which Wren has employed his Roman features and minor details on a carcase presented to him, as it were, with no material permission of novelty, saving in the application of his circular vault and lantern of brick and stone, in lieu of the octagonal vault and lantern, of wood and of smaller dimensions, at Ely.

It may be at once admitted that the nave, choir, and aisles are, under all compulsory circumstances, unimprovable; though strict taste may regret some things those circumstances occasioned. The vaulting, however, over the nave and aisles, formed by flat domes on pendentives, is truly beautiful. The great cupola, in its expression of expanse with elevation, has no equal. That of the Pantheon at Rome gives expanse merely, as it is not higher than it is broad; that of St. Peter's is in height more than twice and one-third its width, and we are therefore rather struck with its altitude than its horizontal capacity; that of St. Paul's is something less in height than twice its width, and, bearing also a much larger proportion to the rest of the building than in St. Peter's, it has much greater apparent size. The proportional altitude of the cupola of St. Génevieve, at Paris, is still more than St. Peter's; that of the church of the Invalides something more than St. Paul's. The effect produced by Wren's cupola seems to indicate that its proportions are the best for producing at the same moment a sense of amplitude and loftiness combined.

The whispering gallery of St Paul's, with all above it, leaves nothing in the way of architectural form to be desired; though there are many who think the character of painting adopted most injudicious. Below the gallery, however, criticism rests dissatisfied, if not offended; the four diagonal sides of the octagon beneath the tambour of the cupola, evincing an aim at more than the artist has successfully accomplished. To obtain an appearance of open lightness, developing the architecture and vaulting of the aisles behind them, these diagonal compartments are woefully cut up, and finished with ingenuity at the cost of judgment. It had been better if these four compartments had simply exhibited repetitions of what is practised in the nave, choir, and transepts, so far at least as was possible. There is no occasion for more than simple reference to defects which have ever been obvious to the critical eye. The confusion of these parts is positively so distressing, that alteration would be justifiable, only taking scrupulous care that it be effected by that "repetition" of Wren's own to which allusion has just been made. St. Peter's had many architects. The substitution of a better piece of Wren for another, in the same building, would not disturb the oneness of itself or its designer.

The partial but too apparent defect just noticed, very probably grew out of the meddling obstinacy that insisted on the old cathedral form, but still it may not have been imperatively occasioned; for in the cathedral of Ely no corresponding defect appears, and in the great church at Rome we feel no desire for other than the solidity of the four diagonal piers under the dome. In St. Paul's however, as at Ely, there was space for diagonal openings answering to those of the nave, &c., and so far was it advantaged beyond St. Peter's; for unquestionably the means afforded by such openings for the uninterrupted perspective of the aisles from end to end of the entire interior are valuable.

If the architecture of Wren, as illustrated by St. Paul's, be judged with generous allowance for compulsory restrictions, the result can be nothing less than deferential admiration.

And now a few words on the thoughtless cavils that have been raised on the subject of the double dome (we might as well say the triple dome) of St. Paul's.

The dome of the Pantheon at Rome, having nothing but itself to support, is a simple vault of masonry, so low in proportion, and so immensely buttressed, as to be prepared for an earthquake.

The dome of the Florentine cathedral is so highly pointed as to approximate towards the cone, and it is therefore the more fitted to bear the stone lantern at the top.

The dome of the Baptistery at Pisa is formed of a lofty internal cone, supporting the outer vault or hemispherical covering.

The non-appliance of constructive knowledge in the dome of St. Peter's at Rome was felt before it was finished. The lantern was made less than originally intended, but still it proved too heavy for the great vault that could hardly find safety for itself alone, and it has only been preserved to our wonder by hoops of iron—the means taken by Wren to secure the safety of Salisbury spire.

Our scientific architect had marked the failure of the Gothic architects in their deficient regard for lateral thrust. He had observed how fearful might be vertical pressure on a domical vault. Whether he was acquainted with the Florentine and Pisan examples we know not; but if not, he had intuitively the knowledge they would have afforded him.

He had to place upon the top of his dome a stone lantern, with its ball and cross measuring some ninety feet in height. He therefore adopted the principle of the Pisan Baptistery. He constructed his inner brick cupola of the form and altitude he considered best for internal effect. Over this he built a cone, just free from pressing on his cupola, and he carried it upward till it met the required width for the base of his lantern; finishing his cone with a domed top, as at Pisa. This being determined, the attic story of his tambour arose to press down upon the common springing of cupola and cone; and not to remedy a defect, but "to make assurance doubly sure," he applied his hooping chains of iron. To protect the cone a roof was necessary, as that which covers the vaulting of his nave and aisles, and of the same material, *i.e.* wood and lead; the purpose of protection and endurance being precisely the same in both cases. Apart from what Roman design requires—apart from the majesty of the hemispherical form,—is there a man breathing who would cover a circular cell and its cupola-vault with anything but a hemispherical roof, as the best for affording the perpendicular weight of leaded timber upon the buttress of the cone, with means for effectively confining from bulging, either in or out, the masonry of that cone? The high Gothic dome of Florence is not admissable in pure Roman design; but a lantern, ponderous as that of Florence, is required. The simple hemispherical dome will not safely support such a lantern. The Pisan mode of construction suggests the mode of security. So much for mere construction.

Now for the matter of taste. Is there any reason for such scrupulous honesty, as shall shrink at the idea that the beholder may be deceived in thinking that the ceiling he sees within the building is the mere inside of the shell he sees without? May he not separately think of what is beautiful without and within; and contemplate distinctly the perfection of both, with a comfortable conscience as to the filling of the intervening space, especially when he knows that concealed work is necessary to his admiring in safety? If the spectator, amazed at the dignity of bulk and altitude without, gives to the expanse within the credit of equal size and altitude, is it not better than well? Is it not a fair illustration of the *ars est celare artem?* There is surely no need to be argumentative on this absurd question any longer. In every sense, artistic as well as scientific, the dome of St. Paul's (so far as the architect is concerned) is the transcendent example of perfection in its kind. Its cupola is the firmamental beauty of the cathedral's interior; its dome is the glory of its extern, and the fitting crown of the metropolis of England. It will be time enough to insist upon it that a church dome shall be simply an inverted cup of masonry, when all the remainder of the building shall have no roof but the vaulting which forms its ceiling.

It may be lastly said that the lead-work of St. Paul's dome is eminently beautiful in the form of its ribbed or fluted decoration; and that the lantern, with its iron gallery and gilded finial, have never been regarded but as deserving eulogy.

It is curious to observe that Wren, though opposed in his desire to avoid (as unsuitable) the general form of the Gothic cathedral, seems to have met with no antagonism in any remnant feeling for the Gothic style of detail. Neither his immediate patrons, nor the public, appear to have retained the least regard for it. Inigo Jones, who began under some degree of its influence, had so far rejected it as to affix a Corinthian portico to the old Gothic St. Paul's; and it is only unfortunate that any attachment to the ancient disposition of ground plan should have outlived all care for the old character of elevation. The Roman Catholic Duke of York, not having a word to say for the Gothic style of art, only insisted on the ichnographical arrangement suited to the imposing ceremonies of the worship he desired to restore; and the issue was disastrous, for it impeded the perfection of a modified Classic development at the price of Gothic degradation. Not a word can be said in favour of Wren's Westminster Abbey towers; but there is enough in his spire of St. Dunstan's, in the tower of St. Michael's, Cornhill, and in the bell tower of Christ Church, Oxford, to show that Wren's genius was "assailable" on the Gothic tack, had the wind of popular inclination at all served in that direction.

The estimate of Wren's architecture will be the more favourable as our consideration is confined to his select works, or rather to certain works selected; nor will it argue an unfair partiality in

Digitized by Google

our choice, if we put aside his buildings at Cambridge, his hospitals of Greenwich and Chelsea, with others of his public and all his private edifices; leaving, in addition to his design for St. Paul's, nothing more than the principal of his other London churches.

Now, if Wren had been the author of nothing more than the interior of St. Stephen's, Walbrook, his claims to architectural fame would have met with warm acknowledgement. Let us at once admit the cupola panelling to be improvable, and the springing of the diagonal arches across the rectangle formed by the entablature below, a liberty only justified on the plea that without it we could not have had what we value as a beauty not to be spared. By the *complex-simplex* of the interior a charm is produced, rendering it perhaps the most triumphant *multum in parvo* to be found in Europe. The simple parallelogram of the plan resolves itself in its upward stages into two distinct cruciforms, till a cupola crowns the octagonal centre. Here we have the symbol of the Christian church as the superstructure of a square ground floor; the space of which, as an auditorium, is interfered with to the least possible amount by unstinted architectural sufficiency. The vertical proportions of the section are not less happily considered. Not grandeur, but the perfection of constructive lightness and Corinthian elegance, is manifested in this hall of the sixteen (looking like sixty) columns. Out of the precisions of geometry have here grown, apparently, the freedoms of natural grace; till the feeling and imagination of the artist are not less notable than his ingenuity and mechanical skill; and the entire result is an architectural gem of such form and quality, that it is only left us to wish the jewel were more worthily inclosed.

Of equal merit in a different way is another interior—like the former simply inclosed in a mere box of brick and stone—the church of St. James, Piccadilly. Here is less playfulness of fancy, because the occasion admitted not so much, or at least required it not; the demand for galleries altering the conditions under which an architectural character was to be given; but take it with those conditions, and the church in Piccadilly is as decidedly a masterpiece as that in Walbrook. The way in which a maximum of space in every direction is obtained, with a minimum of filling, is admirable. Being done, the extreme simplicity of the result looks like the mere obvious production of common sense; and it requires some consideration to estimate the power of ready invention that lies concealed under an aspect so little denoting any extraordinary exercise of ingenuity. In the church of St. James especially, a free, noble, and elegant piece of art has derived itself from a sound, economic, and scientific process of construction. The carpenter here co-operates with the artist in the production of a model wherein commodiousness and beauty were perhaps never before so felicitously combined. The roof is unimprovable, and the superficial work that internally cases it is as the outer grace of the human form, which attests the skeleton's perfection.

It is, after all that has been done or argued by Classic or Goth, a question whether St. James' Church, Piccadilly, does not present the most perfect model of a Protestant church-interior in existence. Wren's observation had led him to the conclusion, that no more than 2000 persons could be accommodated in a single room, with pews and galleries, so that all might distinctly see and hear the speaker. In this church he "endeavoured" to provide for such a number, in a manner consonant with architectural dignity and beauty. That he failed not in his "endeavour" will be allowed by every one who first considers the architect's intention and the building's purpose; and then contemplates the artistic way in which both have been fulfilled.

In the church of St. Bride, Fleet-street, we have much more external pretension than in those of Walbrook and Piccadilly, while the interior exhibits a character distinct from either. An equal aptitude to every variety of form, with a perfectly new spring of invention, is observable in every fresh call upon the architect's genius. Though St. Bride's interior (saving only in length) is inferior in magnitude to St. James', it is of more complex character; partaking, in the disposition of parts, of the old cathedral choir, the arcades being surmounted by clerestory ranges, and the ceiling of the aisles groined after the old fashion. The coupling of the columns under the arches, and their clustering with those which support the galleries, are free imitations of the Gothic compound pillars; and we may regard this example as having been probably influenced by the wishes of the then "high church" party, who retained a partiality for the clerestory. Wren was the originator of much that others have since imitated; and if it be said that he had also received many suggestions from elder artists, let us call for recent examples to show the same improving use of Wren that he exhibited in the use of his predecessors.

The steeple of St. Bride's Church *alone* does not assert the strength of his genius, nor the play of his fancy, so much as his judgment and taste, in producing an elegant arrangement of simple and resembling geometrical forms, within an outline of unimprovable grace. In certain other examples, we observe the free pencil of the artist tracing fluent lines of beauty; in this, we see how the rule and compasses of the geometrician have rather been in operation, though to a result leaving us to wish for nothing else in its stead. The gradual increase of open work and decoration, in the ascent of its elevation from the base to the crowning obelisk, is charmingly effected; and though this spire, like a Chinese pagoda, is little else than a repetition of octagonal chambers successively diminishing in their rise, still the retention of their vertical lines in concentric progression so far unites them into an unbroken whole, as to correct the objection which might be (critically) taken to a pile of distinct (though resembling) parts. Let us grant Wren has here aimed at what can only be thoroughly perfected in a Gothic spire; it is enough, the beauty accomplished is proved compatible with Italian detail. There is moreover this to be said of the Italian steeple, that it admits of a distinct variety peculiar to itself; *i. e.*, not only a difference but a distinction, as marked as in things of separate kinds. Even when the general outlines of two Italian spires may much resemble each other, this distinction may be preserved, so as to "tell" no less in a distant than in a near view; and the advantage of this (pictorially speaking) in a city of many spires, must be obvious—to the painter's eye at least.

The steeple of Bow Church, Cheapside, is little short of perfection, as an adaptation of Classic detail to a general form, whose vital principle is that continuous verticality which can only be fully carried out in the Pointed style; and it may be truly affirmed, that this principle is displayed with more completeness in the spire of St. Mary-le-Bow than in many Gothic examples of distinguished celebrity, wherein we see a connection of tower and spire without that combination which by artistic management renders the united two a single entirety. Where a steeple has more than one great part, the graduation necessary to complex beauty requires at least three components; and, as in the case of Bow Church, it will be better to have four or five. As in other of Wren's works, the graces of this steeple grow out of, and, as with natural luxuriance, overspread the form perfected by constructive science. The section shows why the elevation is what it is; and the successive plans of each story as truthfully superimpose one above the other as the ascending parts of the human frame. Not a feature is eccentric: each stage rises from out of its inferior and into its superior, as thought from and thought in the eloquence of a perfect orator. It is true the whole may be taken to pieces; *i. e.*, the pieces are separable; but no portion has, distinctively, one fiftieth part the beauty of the five collectively;—the basement, the bell-chamber, the circular peristyle, the rectangular composition next above, and the crowning obelisk. These in their individual and relative forms and proportions, are the felicitous results of as many fresh thoughts co-operating in the development of one idea.

Though Wren's pointed architecture cannot (either critically or opprobiously) be called Gothic, we may yet refer to three or four examples having, in their nondescript character, a merit of their own. There is a picturesqueness in the bulk and form of the bell tower of Christ Church College, Oxford, which we should be loth to change for anything more justified by Gothic precedent; and in the tower of St. Michael's, Cornhill, we recognise a successful aim at effectiveness, and a feeling for masculine beauty, which are scarcely the less noticeable because expressed in very indifferent grammar or uncertain language; but it is to the steeple of St. Dunstan's in the East that we would especially allude as an example of supreme grace. In the bodily form of its combined features little improvement can be suggested. Supplant the little cappings above the flying buttresses by small pinnacles; apply engaged pinnacles where the square diagonal buttresses of the tower resolve themselves into the angle octagons; then Gothicise the square panellings of the minor horizontal compartments of the tower, and the old example of St. Nicholas, at Newcastle, will be the more favoured by non-comparison; for, even as it is, the venerable "legitimate" would show but indifferently beside his bastard successor.

Digitized by Google

In St. Dunstan's, as in the steeple of St. Mary-le-Bow, beauty is the result of taste operating on constructive perfection; nor has the former example any existing rival in simple and elegant delicacy combined with such an expression of enduring strength. Considered Gothically, this beautiful design has (as we have seen) some minor defects, which however, as Gothic feeling pervades, are injuriously important. Let but the true Gothic artist, by the minimum of required excision and addition, correct these defects, and we should probably have an example of what Wren would have done as a Goth of our present day. The circumstances of particular times will influence the mode in which genius displays itself; but whatever be the mode, the display should be obvious; and we can only lament the bluntness of the perception which cannot pierce through a partially defective manner to rest with due admiration on the material excellence that nevertheless exists.

It has been the purpose of this essay, first, to show that Sir Christopher Wren was a man of *genius* in the full sense of the word, namely, that talent which would have rendered his name famous though he had achieved no architectural celebrity whatever. Secondly, to do justice to the *man*, by considering his architecture under all the circumstances of its production; his lack of especial preparatory study; the sudden call upon him for so vast an amount of occupation, with its ever-attendant responsibilities, and its too frequent mortifying vexations, particularly in the case of the one great building, which is therefore the monument of his skill under difficulties, but not the just representative of his unshackled artist feeling. Thirdly, to do justice to his *architecture*, without reference to any consideration but that of the unchanging principles on which everything in art that is lasting (and therefore true) is philosophically founded.

It is admitted that Wren's fame as an architect would not be exalted by a strictly critical estimate of all the buildings not particularised in the foregoing pages; though there be some, and parts of others, which have merit balancing the absence of it in the rest. But the examples we have noticed sufficiently attest his power on great occasions, the mastery by which he gave importance to those of less import, and the ingenuity with which he made artistic taste and feeling combine with science in certain others which exhibit more especial originality.

Had we an account of all the circumstances attending the erection of each building, we should probably have rather to sympathise with the architect's vexations than to arraign his taste; but Wren thought too modestly of his own works and too humbly of himself, to care for more than the exercise of his best efforts, under the favourable or unfavourable auspices affecting them; content to abide, without any defensive explanations on his part, the judgment which discriminating criticism would pass on his works as a whole.

Doubtless the genius of this great architect was influenced by the moral goodness of his character, by its philosophic gravity, and, more than all, by its religious equanimity; nor can we but delight in thinking upon Christopher Wren as the supreme exemplar of the Vitruvian model; worthy, in every sense, of his own self-erected mausoleum, and of the noble epitaph by which his son confirmed its dedication.

PATENT HYDRAULIC PURCHASE MACHINE FOR CRONSTADT DOCK.

UNDER the direction of the Russian government a great slip dock is being constructed at the port of Cronstadt, and for this dock Messrs. More and Son, engineers, Glasgow, have just completed one of their immense hydraulic purchase machines. The slip now in course of erection at Cronstadt has an incline of 1 in 32, and the hydraulic machine, which is to be used in drawing vessels up the slip, is capable of overcoming a force of 3000 tons of dead weight. The principal feature of the purchase is a hydraulic cylinder fastened securely to a firm foundation at the upper end of the slip. It is fitted with a moveable ram working through cupped leathers at the neck. Two side rods proceed from a cross-head on the end of the ram along the sides of the hydraulic cylinder to a tail plate, to which are also fastened the traction-rods connecting the purchase with the cradle on which is the vessel to be drawn up. Three force pumps are worked from the engine shaft, which pump the water from the pump cistern, and force it into the hydraulic cylinder. A large discharge pipe with a powerful cock and lever allows the water to be again returned to the cistern—the water being used over and over again. A back weight attached by a chain to the top of the ram descends into the recess in the foundation, and gives the ram the reverse stroke when the discharge cock is opened. The mode of action appears to be very simple. The cradle having been run down the inclined plane or slip, and the ship blocked up upon it, the traction-rods, which are usually of the same length as the stroke of the ram, are then attached to the cradle and to the purchase machine at the head of the slip. The steam engine is then set in motion, when the pumps force the water from the cistern into the hydraulic cylinder, the pressure of which forces up the ram, and draws up with it the cradle with the ship upon it. When the ram completes its stroke, the first traction-rod is disconnected and the discharge cock opened, when the back weight instantly draws back the ram, ready to take hold of the next rod, which being attached, the ram immediately again ascends; and so on, the hauling up being continued till the vessel is properly on the slip. By this powerful machinery the largest steamships or ships of war can be drawn out of the water, and placed high and dry, with great expedition. Formerly slip docks were principally used for the merchant navy; but now that the hydraulic purchase machinery has been applied there is no limit to the size of ships which can be taken up on docks of this kind; and they are coming into use in government dockyards instead of graving docks. It is stated that the Russian government contemplate erecting docks of this description at all their principal naval stations. The hydraulic purchase machinery is patented by Mr. Daniel Miller, C.E., of Glasgow.

SCREW PROPELLERS.*

FROM the recently published 'Engineering Precedents' of Mr. Isherwood we take the following account of certain experiments conducted in the British war-ship Conflict, to test the relative merits of various forms of screw propellers. The analysis obtained by Mr. Isherwood, of which as will be seen the main result is that propellers of various forms differ little in efficiency, is very interesting. We confess however to some misgivings as to the accuracy of the process by which the powers exerted on the propeller and hull respectively are computed. It is to be considered that the complete determination of this question would involve a hydrodynamical investigation of the greatest analytical difficulty, and the accuracy of the method here proposed is by no means obvious. It is to be regretted that the author has not stated more precisely the nature of the several resistances by which the screw is here supposed to be affected. Are "the power required to overcome the resistance of the water by the screw blades," and the power required by the "slip of the screw," intended to measure the independent resistances to the rotation and progression of the screw respectively? If so, we do not at present see why the latter is to the power required to propel the hull "in the ratio of the speeds of the screws to the speeds of the vessels;" and we imagine that there would be considerable difficulty in establishing the proposition here assumed.

Another difficulty arises from the uncertainty as to the steam pressures shown by the indicator. When the motion is rapid, the pressure of the steam is not the same in every part of the cylinder simultaneously, and the momentum of the indicator when in motion renders it a very dubious record of *statical* pressures.

We have not given the whole of the table presented by the author on account of its length, but the following explanations are sufficiently clear by themselves. The screws experimented upon were five in number—were each of a uniform pitch, two-bladed, and 13½ feet in diameter. The trials of them were all made at sensibly the same draught of water, and at a measured mile.

"The Boomerang is in fact a two-bladed true screw, with one blade inclined forward and the other inclined backward, and it will produce exactly the same propulsive effect as a common screw of the same diameter, number of blades, pitch and projected surface; but it will be economically less efficient than the common screw, from the fact, that owing to the inclination of the blades towards the axis, the helicoidal surface will be greater in the ratio of the hypothenuse to the perpendicular of the right-angled triangle made by the blades with the axis, and consequently the power expended in overcoming the cohesive resistance of

* 'Engineering Precedents for Steam Machinery.' By B. F. Isherwood, Chief Engineer, U.S. Navy. New York: Baillière. 1859. 8vo.

Digitized by Google

the water by the blades will be proportionately greater. The only peculiarity that distinguishes the Boomerang from the common two-bladed screw, lies in the fact that one blade is inclined forward and the other aft, thus making an acute and an obtuse angle with the axis, instead of standing at right angles to it. By this arrangement the water is pressed by one blade towards the axis and by the other blade from the axis; now it is evident that if anything is to be gained by inclining the blades, both blades should be inclined in the same direction, for if equally inclined in opposite directions, as with the Boomerang, the gain by one, if there be any, will be balanced by the corresponding loss from the other. In fact, however, the inclination of the blades fore and aft produces no other effect than the serious practical inconvenience of requiring a much longer screw to obtain equal propulsive efficiency; and of course requiring a proportionally longer opening in the dead wood of the vessel.

Explanation of the Table containing a Summary of the Experimental Results.

"In the preceding pages the experiments with the different screws applied to the Conflict have been discussed in strict accordance with the observed data, which is remarkably correct, the deviations from truth being so slight as to occasion no error of sufficient importance to be of practical consequence; nevertheless, in order to appreciate with precision the relative economical efficiencies of these screws and to exactly distribute the power used with them, I have grouped them in the annexed table, where will be found both the observed data and its rectification by calculation, together with an exact distribution of the power in the different cases for a uniform speed of vessel of 9 knots per hour. These rectified results being all obtained by the same process and for the same values, are strictly comparable, and determine perfectly the relative efficiencies of the screws, and the causes of the same.

"Columns 1, 2, 3, 4, 5, 6 and 7 contain the dimensions of the screws, from which it will be seen that the experiments embraced variations in their pitch, in the fraction used of the pitch, in the outline of the blades and in their inclination to the axis; also the substitution of a large globe for the hub and central portions of the blades. These columns in connection with the foot notes sufficiently explain themselves. The fractions used of the pitch in column 5 are what are due to the surface and efficiency of the same, calculated as the square of the distance of the surface from the axis.

"Columns 8, 9 and 10 give respectively the *observed* number of revolutions made by the screws per minute, their slips in per centum of their speed, and the speed of the vessel per hour. Column 11 contains the slips of column 9 rectified in accordance with the pitches and fractions used of the pitch; the mean of all the experiments being taken for the standard or starting point, from which the several rectified slips are deduced from a logarithmic curve. Column 12 contains the *true* experimental speeds of the vessel, derived from the rectified slips of column 11 and the observed revolutions of the screws in column 8, which are assumed to be correct, as they were taken by a counter worked by the engine.

"Columns 13, 14 and 15, contain respectively the observed number of double strokes of engines' pistons made per minute; the mean gross effective pressure by indicator in pounds per square inch of pistons; and the gross horses-power developed by the engines. This data, it is to be regretted, was only ascertained in the cases of screws A and B, and from their mean has been reduced the power 452·57 horses required to propel the simple vessel at the speed of 9 knots per hour, as contained in column 27. Columns 16 and 17 contain respectively the mean gross effective pressure in pounds per square inch of pistons, and the gross horses-power developed by the engines for the true experimental speeds of vessel contained in column 12: these quantities have been calculated from the contents of columns 22 to 27 both inclusive, on the hypothesis that the resistance of the vessel varied as the square of its velocity, and the power required to work the engines *per se* directly as the number of double strokes of piston made in equal times.

"Columns 18 and 19 contain the number of revolutions of the screws and of double strokes of engines' pistons required to be made in equal times to give the vessel a speed of 9 knots per hour; the columns are calculated for the rectified slips in column 11.

"Columns 20 and 21 contain respectively the mean effective gross pressure on the pistons in pounds per square inch, and the gross horses-power developed by the engines required for a speed of vessel of 9 knots per hour, and for the number of revolutions of the screws and double strokes of engines' pistons contained in columns 18 and 19. These pressures and powers are calculated from columns 22 to 27 both inclusive.

"Columns 22, 23, 24, 25, 26 and 27, contain the distribution of the total horses-power required to propel the vessel with the different screws at the uniform speed of 9 knots per hour, and with the rectified slips of the screws as given in column 11. Column 22 contains the horses-power required to work the engines *per se* at the number of double strokes of pistons given in column 19, and for the pressure of 1½ pound per square inch of pistons. Column 25 contains the horses-power required to overcome the cohesion of the water by the screw blades; calculated for the number of revolutions of the screw in column 18, and in the ratio of the square of the velocity of the helicoidal surfaces in their helical paths, for a value of 0·45 pound per square foot of surface and a velocity of 10 feet per second. Column 27 contains the horses-powers required to propel the simple hull at the speed of 9 knots per hour; this power is derived from the means of the indicated powers in columns 14 and 15 for the two experimental speeds of vessel given in column 12, and on the supposition that the resistance of the vessel varied as the square of its velocity. Column 26 contains the horse-powers expended in the slips of the screws, deduced from column 27 for the true slips in column 11, in the ratio of the speeds of the screws to the speeds of the vessel. Column 24 contains the horses-powers required to overcome the friction of the load: they are 7½ per centum of the sum of columns 25, 26 and 27, including themselves. Column 23 contains the horses-powers applied to the screw shaft: they are the sum of columns 24, 25, 26 and 27. Column 24 is 7½ per centum of column 23. Column 21 is the sum of the columns from 22 to 27 both inclusive.

Designation of the screw.	1 Diameter, in feet.	2 Number of blades.	3 Pitch, in feet.	4 Length in direction of axis, in feet.	5 Fraction used of the pitch.	6 Helicoidal area, in square feet.	7 Projected area on a plane at right angles to axis, in square feet.	8 Observed number of revolutions made by the screw per minute.	9 Slips of the screws in per centum of their speed, as ascertained by experiment.	10 Speed of the vessel per hour, in knots of 6,086 feet, as ascertained experimentally.	11 Calculated slips of the screws in per centum of their speed, as rectified.	12 Speed of the vessel per hour in knots of 6,086 feet, calculated from the rectified slips.	13 Observed number of double strokes of pistons made per minute.	14 Mean effective gross pressure on pistons in pounds per square inch, by indicator.	15 Horses power developed by engines, by indicator.	16 Mean effective gross pressure on pistons in pounds per square inch, by calculation.	17 Horses power developed by engines, by calculation.
A	13·5	2	16·500	2·750	0·333	57·653	47·450	68·000	16·02	9·289	17·59	9·116	68·000	14·19	777·50	13·86	759·52
B	,,	,,	15·167	2·528	0·300	50·000	43·520	75·750	16·81	9·424	16·50	9·458	75·750	13·30	812·00	13·19	805·50
C	,,	,,	15·167	2·528	0·290	43·000	38·800	77·000	18·15	9·425	17·38	9·512	77·000	...	...	14·10	874·78
D	,,	,,	19·885	2·486	0·250	46·540	35·587	62·000	21·01	9·600	22·41	9·430	62·000	...	...	16·87	842·67
E	,,	,,	19·885	2·000	0·118	27·837	21·056	65·875	26·25	9·524	25·90	9·570	65·875	...	...	16·92	898·05
Boomerang	,,	,,	20·000	4·000	0·118	30·916	21·056	66·688	26·05	9·724	26·05	9·724	66·688	...	...	17·57	944·22

"Screw A is a common screw of uniform pitch and length from hub to periphery.

Screw B is a common screw of uniform pitch and length from hub to periphery, except that the corners of the blades are rounded off on a radius of 18 inches.

Screw C is screw B with the hub and central portions of the blades inclosed in a globe of 4·75 feet diameter, according to Griffith's arrangement.

Screw D is a common screw of uniform pitch and length from hub to periphery.

Screw E is screw D with its surface reduced in such a manner as to make it equal to in projected area, and to give it the same outline of blade, as the Boomerang.

Boomerang propeller of Sir Thomas Mitchell: the surface of the blades a true helicoid; one blade inclined forward, the other aft; the blades have an irregular outline."

"In examining the foregoing Table of Experimental Results, our notice is first arrested by the slight difference in the economical efficiencies of the screws, although the latter offer considerable diversity of form and dimensions; the lowest efficiency, measured by the power applied to the screw shaft, being only 6 per centum less than the highest. On closer examination we find this to result from the facts that the loss of useful effect by the screws is composed of the sum of the powers expended on the slip, and required to overcome the cohesive resistance of the water by the blades; and that we cannot diminish one without increasing the other. Hence we find, that within moderate limits the economical efficiency

Digitized by Google

remains nearly the same, although the slip may vary considerably, as well as the power required to overcome the cohesive resistance of the water, the one increasing as the other diminishes. With the screws applied to the Conflict, the slips varied from 16·50 to 26·05 per centum, and the power expended in overcoming the cohesive resistance of the water to the blades varied from 2·78 to 9·75 per centum of the power applied to the screw shaft; yet, as above stated, the extreme variation in economical efficiency among their screws was only 6 per centum, measured by the net power applied to the shaft, and if measured by the gross power developed by the engines it falls to 3$\frac{1}{10}$ths per centum; and were it to be measured by the *total* quantities of steam used in the different cases (including the waste in the cylinder nozzles and clearance), which correctly represents the quantities of fuel expended, this variation would be reduced still lower, and in fact, in some of the cases, the relative economical efficiencies would be actually reversed, because the screws giving the lower results in the table being of greater pitch, make fewer revolutions to propel the vessel a given distance, and consequently waste less steam in the cylinder nozzles and clearances, which have not to be filled so often. These remarks, however, only apply when the screws are propelling the normal resistance of the vessel, that is to say, when the latter is uninfluenced by head winds or seas, or having a vessel in tow. In such cases an entirely different scale of relative economical efficiencies will result, owing to the facts—that with a considerable increase of the normal resistance of the vessel, the number of revolutions made by the screw in a given time will with equal steam pressure remain nearly the same, and consequently the loss of useful effect by the power required to overcome the cohesive resistance of the water by the screw blades will remain nearly as before; not so however with the loss of useful effect by the slip, which increases in the direct ratio of the resistance; and if we suppose the normal resistance of the vessel to be increased by a moderate head wind and sea 50 per centum—an ordinary case in practice—then the slips of the screw will be increased one-half also, and a slip that with the normal resistance was only 16 per centum will become 24 per centum, while a slip of 26 per centum will become 39 per centum, the increased difference of the slips being 5 per centum, which is unaccompanied by anything at all approaching proportional decrease in the power required to overcome the cohesive resistance of the water by the screw blades; consequently nearly the whole of this additional 5 per centum of slip tells against the screw of greater slip, and becomes more and more exaggerated as the normal resistance of the vessel is more and more increased. Hence it will be found that the relative economical efficiencies of screws experimented with in smooth water and uninfluenced by wind are by no means the measure of their economical efficiencies at sea, struggling against the vicissitudes of weather, and an average increase of the normal resistance of the vessel from one-third to one-half, according to its size. This important consideration has too frequently, if not always, been overlooked in proportioning screws for marine propulsion; for which purpose the screw of least slip in smooth water is in general the most efficient. But with screws of equal diameter, a marked reduction of slip can only be obtained by lessening the pitch, which involves a greater speed of engine for equal speeds of vessel, and this is a very serious practical inconvenience, especially with large engines, as regards their durability and certainty of action. Some reduction of slip can, it is true, be obtained by employing a greater fraction of the pitch, but this involves, if carried beyond four-tenths even in extreme cases, a disproportionately increased loss by the power required to overcome the cohesive resistance of the water; it also involves the no less serious practical inconvenience of increased length and weight of screw.

"Under the conditions of the experiments, the screw giving the highest economical result was screw B, which had the least slip, namely 16·50 per centum; it had also the least pitch, and was composed of the fraction $\frac{3}{10}$ths of the pitch; yet this screw, if we omit the exceptional screw C, expended the greatest amount of power in overcoming the cohesive resistance of the water, namely, 8·53 per centum of the power applied to the screw shaft. We find also that every increase of pitch and consequently of slip was attended with a decrease in the economical efficiency, notwithstanding that with the increased pitches the power expended in overcoming the cohesion of the water was reduced by reducing the fraction used of the pitch. The sum of the losses of useful effect by slip and by overcoming the cohesion of the water with screw B, was (13·85 + 8·53 =) 22·38 per centum of the power applied to the shaft; and as this could not have been reduced by any further reduction of the fraction used of the pitch, it may be taken as the minimum obtainable with the given pitches, diameter, and resistance. Hence, under the conditions of the experiments, $\frac{3}{10}$ths is the proper fraction of pitch to be employed in conjunction with a slip of 16·50 per centum.

"In the strictly comparative experiments with screws B and C—which were the same, excepting that in C the hub and central portions of the blades were inclosed in a globe whose diameter was 35·2 per centum of the diameter of the screw—screw C gave a less economical efficiency of 2$\frac{1}{2}$ per centum, owing to the facts that the decrease of the blade surface, although made immediately around the axis, increased the slip, while the power expended by the globe in its rotatory movement to overcome the cohesion of the water, was greater than what would have been expended for the same purpose by the inclosed central portions of the blades moving in their helical paths. In addition to these increased losses, there is also the greater direct resistance of the large globe to the forward movement of the vessel, than what is opposed by the end of the ordinary hub and the sharp edges of the screw blades. Hence we find, that as this form of screw offers no practical advantages and entails considerable economical losses, it should never be employed except when feathering blades are used, in which case it is absolutely necessary for containing the mechanism that moves them.

"In comparing screws D and E, which are the same in function of form, excepting that the former employs the fraction 0·25 of the pitch and the latter the fraction of 0·118 of the pitch, we observe that the relative economical efficiency of screw D was 2 per centum greater than that of screw E, the slip of the former being 22·41, and that of the latter 25·90 per centum; whence appears, that in these cases the increase of slip was not compensated by the decrease in the power required to overcome the cohesion of the water due to the lesser surface; consequently, with slips of 22·41 per centum and over, there results a loss of economical efficiency by reducing the fraction employed of the pitch below 0·25.

"In the strictly comparative experiments between screw E and the Boomerang propeller—which are quite fair, inasmuch as whatever pitch, fraction of pitch, diameter, or outline of blade may be employed for the one can be employed for the other—screw E had very slightly the greatest economical efficiency, owing to its blades having less helicoidal though the same projected surface as the Boomerang, resulting from the fact that the screw's blades were perpendicular to the axis, while the blades of the Boomerang were inclined fore and aft to the axis. The Boomerang from this cause has also the great practical inconvenience of requiring much more length (in the one experimented with double the length) fore and aft in the dead wood of the vessel, in order to accommodate the fore and aft inclination of the blades; if its blades be not made with this inclination it is no longer a Boomerang, but a true screw.

"From the experiments with screws C and E, and the Boomerang, it appears how useless are any attempts to increase the efficiency of screws by modifying the outline of the blades; no taperings of the latter out or in, or inclinations of them from a perpendicular to the axis either in a longitudinal or lateral direction, and no removals radially of the surface by the substitution of globes around the hub, or by other means, can add anything to the propulsive efficiency of the helicoidal surface, and they generally entail serious practical inconveniences. The only improvement possible on the true screw of uniform length from hub to periphery, is that due to the use of an expanding pitch or curved directrix."

SIMPLE METHOD OF CALCULATING EARTHWORK.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

In your last number, Mr. J. D. Ridley claims to have used for "some years" the same method of calculating earthwork which appeared in your issue for May. He never looked, he says, upon his application of it as a "discovery." Why then, when it has been made public, does he want to establish priority of discovery? At what precise date Mr. Johnston first used it I do not know; but it has, I believe, come to be an accepted rule, that he who first publishes a discovery, or a new application of known elements, is entitled to have his name primarily attached to it. If the method was "first suggested" to Mr. Ridley in 1846, why did he not make it known? It is a neat and expeditious method, beyond any that I know of; but Mr. Ridley would have kept it all to himself, and might have died with it.

Mr. Ridley further says, that he "thought it would be sufficiently obvious to any person with a slight knowledge of mathematics." And yet, strangely enough, there was a time when it "first suggested" itself even to him. It first seemed a "near approximation," and gradually, upon further investigation, "the exact contents." How then should this method seem "obvious to any person with a slight knowledge of mathematics"? A knowledge of mathematics is not necessarily an *organon* of discovery. Nor has this method, I believe, suggested itself to any writer on Railway Engineering. The character of a *great* discovery is not claimed for it; but as a concise, plain, and certain method for horizontal cross-sections, there is perhaps nothing equal to it. And it only requires to be made known to be generally used.

Aberdeen, July 1859. ALEX. S. WILSON.

THE PUBLIC WORKS OF THE UNITED STATES.

It has been fashionable to compare unfavourably the works of this country with those of Europe. To such an extent has this been carried that it is not unfrequently said that we have to look to England or the continent for most of our examples. We are continually told by travellers of the great extent, beauty, and durability of the continental works, and of the enormous strength of the English structures. Now it is perfectly true that Europe can boast of railroads, canals, bridges, and aqueducts unrivalled in the world for beauty and excellence of workmanship

Digitized by Google

and design, but it is equally true that America can point to works of utility that, in the magnificence of their proportions, are not exceeded anywhere.

The Julian Aqueduct, of Rome, is two miles longer than the Croton Aqueduct, of New York, built by John B. Jervise and Horatio Allen, but the Croton carries more water than all the seven aqueducts of Rome put together, and more than any other aqueduct in the world, and is longer than any other excepting the Julian.

The Illinois Central Railroad, built by Col. Mason, is the longest line ever constructed by one company, and in point of workmanship is equal to any European road.

The National Road over the Cumberland mountains, built by the United States Engineer Corps, is more extensive and durable by far than the Appian Way.

The stone arch over Cabin John's Creek, on the Washington Aqueduct, built by Captain Meigs, is about fifty feet greater than any other stone arch in the world, and is more beautiful in proportion than the arch over the Oca, so long celebrated for its magnificence.

The tunnel built by Mr. Haupt, on the summit of the Pennsylvania Railroad, was a more difficult work than the tunnel under the Thames.

The structures on the Baltimore and the Ohio Railroad at Harper's Ferry, and beyond the summit, built by Latrobe, and the Starrocca Viaduct on the New York and Erie Railroad, built by Julius Adams, are equal in magnificence and excellence of workmanship to anything Brunel ever did in England, or Moran in France.

The Suspension Bridge over the Niagara River, at Lewiston, built by Major Serrell, is 1042 ft. 10 in. in one span, and is 43 feet greater than any other single span in the world, being nearly twice as great and quite as strong as Telford's celebrated bridge over the Menai Straits in England.

The United States Dry Dock at Brooklyn is the largest dry dock in the world by many feet. The workmanship, done under the direction of Mr. McAlpine and General Stuart, is equal, if not superior, to anything of the kind anywhere. The plates of iron used in the gates of this dock are the largest that had been made up to the time they were rolled.

The flight of combined locks on the Erie Canal, at Lockport, built by the State Engineers, is equalled only in one other place in Christendom,—Sweden.

The Railroad Suspension Bridge, built by Rœbling, over the Niagara, is within a few feet of twice the span of Stephenson's great Tubular Bridge in England, the largest structure of the kind. It is 800 feet in one span, and is two stories high, the railroad being above the public highway. Nothing like this exists anywhere else.

The Lighthouse on Minot's Ledge, being built by Captain Alexander, is in a more exposed situation, and, as far as proceeded with, is more securely bolted together, than the famous Eddystone Lighthouse in England.

The Bridge at Wheeling, built by Charles Ellet, is exceeded only in span by the Lewiston Bridge, and is heavier than it; it is the second largest span in the world, and is much more beautiful than the Fribourg Bridge, its European rival.

In carpentry we are unexcelled in the world. Such structures in timber as the Dry Docks at San Francisco and Philadelphia, McCullam's and Col. Seymour's bridges on the Erie Railroad and branches, the timber viaducts on the Cattawissa Railroad, built by Stancleff, Col. Long's bridges on the various New England railroads, and How's trusses at Harrisburg, have not their equals across the Atlantic.

Then, again, in Europe many structures are built that might have been avoided—a few hundred rods of detour would have saved the great Box tunnel. Now we maintain that the location of Sidell's division, for example, on the Erie, evinced more skill in avoiding the necessity of great structures than could be shown in building them.

The stones on either corner of the Exchange in Boston, built by Rodgers, are larger than any single stone in Cleopatra's Needle; and those now being put into the United States Treasury at Washington, are much heavier than any stone of Pompey's Pillar, or the Pyramids of Egypt.

As to the difficulties of location, there is no country where more science and skill have been brought to bear than in ours, and it is a remarkable fact that, in point of time, last year, our average travelling was faster by two and a half miles per hour than in England, comparing our principal lines with theirs, while the charges on the American lines were but little over half the English rates.

The reason why these things are not generally known is, that here we build a great work, announce its completion in the same advertisement that heralds the opening of the road, and no more is said about it, except perhaps what may appear in one or two scientific periodicals, where dry feet and inches, stress, strain, and torsion are discussed, and are never read except by the professional engineer. While on the contrary, in England and France, as soon as a great work is built, and while it is being erected, pictures by thousands are published, medals are struck and circulated, glass models are made, and the illustrated newspapers show it in every stage of progress and from every point of view; the engineer is knighted, if he is not already of the nobility, and the fame of the structure is sent from land to land; while with us, as we have shown, may be found some of the most gigantic works ever undertaken, that are passed by and over without hardly any notice. It is remarkable that the best popular descriptions of our own public works of great magnitude are to be found in the journals of France and Germany.—*New York Times.*

WATERGLASS, AND ITS PROPERTIES.

(Concluded from p. 217.)

One of the most important applications of waterglass is, no doubt, that for painting, based upon its property of causing colours to adhere well, and of imparting to paintings, as well as to coats of paint, great durability and indestructibility. I call this kind of painting *Stereochromy.* It designates that method of painting in which waterglass serves as the connecting medium between the colour and its substratum.

For *monumental painting* it rivals and will eventually supersede fresco-painting. I am told that it has gained considerable ground in Prussia; that fresco-painting has in several cases been abandoned, and that mural paintings which are in course of execution are done by the stereochromic method. In England also this method is reported to receive great encouragement. The so-called encaustic painting cannot be compared to it.*

At Munich, the metropolis of German art, it has not met with much favour, although first discovered at that place,—perhaps, *because* it was first discovered there.

Before I proceed to the application of waterglass in stereochromic painting, I should like to make a few more preliminary remarks.

I was first induced to investigate the soluble silicates by the many complaints which I heard in regard to fresco-paintings, especially as to their want of stability in our severe climate. I speculated as to whether colours could not be made to adhere better and more firmly upon the walls by means of waterglass than by means of lime. This led to experiments, which sometimes confirmed, sometimes negatived, the opinion I had conceived of its applicability. Many difficulties had to be overcome. Had I been able to paint myself, it would have saved me much unnecessary labour; for, owing to delays caused by submitting the various waterglasses to the judgment of others, much valuable time was lost, so that five years were spent over a great number of experiments,—expensive, though for the most part unsuccessful,—until I arrived at the desired end by the aid of Herr von Kaulbach's unceasing co-operation, and the lively interest shown by him in the new discovery.

It appears strange, indeed, that so much time and labour should have been occupied upon a discovery which in reality is so very simple, as will be seen by the following description.

It was found in the course of this investigation that stereochromy can be employed upon other substrata as well as upon walls, and that even easel pictures of moderate size can be advan-

* The paintings excavated at Pompeii were formerly thought to be of an encaustic nature, and various efforts were made to imitate them, but without result, since they were, in fact, real frescoes, as was conclusively shown by Professor Schafhautl (see 'Augsburger Allgem. Zeitung,' of January 6 and 7, 1845; 'Beilage,' p. 42, fol. 49; and Dingler's 'Polytechnical Journal,' vol. xcv. p. 76.) Nevertheless endeavours have lately been made at Munich to carry out large and expensive paintings in a certain encaustic style. How great a retrograde step in monumental painting was this! The paintings brought to light at Pompeii cannot be preserved long, but gradually decay. In order to protect them, they have been impregnated with wax and brushed over with sandarac, which deprived them of much of their original beauty. Would it not have been better to impregnate them with waterglass, which, no doubt, would render them more durable without depriving them of their freshness? Carbonate of soda which effloresces might be wiped off with a wet sponge, after which the painting can be washed with distilled water without fear of injury.

Digitized by Google

tageously executed; moreover, that stereochromic paintings and coatings of paint may be put upon certain grounds directly, *i. e.*, without a substratum of cement.

Mural or Monumental Painting upon a ground of Mortar-cement.

To produce a stereochromic picture of great beauty and permanence upon a wall, it is chiefly necessary to look to the *foundation* of the picture, which consists of a *lower* and an *upper* layer of mortar-cement. Errors which are committed in their preparation throw obstacles in the way of a painter and injure the beauty of the painting. The principal and most important operation in forming the ground-work, consists in imparting to the mortar-cement a thorough and stone-like solidity, and a perfect adhesion to the wall, at the same time rendering it capable of absorbing the waterglass in all its parts with equal avidity. The first layer or substratum is formed of ordinary lime-mortar; its object is to equalise the unevenness of the wall, and to cover well the stone. The sand ought to be of even grain, neither too coarse nor too fine, and it may be either calcareous or quartz sand. It is, however, necessary to wash either kind well before using it. The lime must be properly slaked and sparingly employed, so as to render the cement—which must be made up with distilled or rain water—rather poor than otherwise. A rich cement would not absorb the waterglass readily, and will sometimes cause it to crack.

The plaster covering thus prepared requires to be well dried and exposed to the air for several days in order that it may absorb carbonic acid and be converted into basic carbonate of lime; for if the lime in this cement be perfectly caustic, the waterglass would subsequently be decomposed by it, and would not penetrate to the wall—a matter of necessity if a good cementation is to be effected.

The saturation of the lime with carbonic acid may be accelerated by moistening the wall several times with a solution of carbonate of ammonia. When it is dry and the ammonia evaporated, waterglass may be employed to make it adhere to the wall. The application is repeated several times, allowing the surface to dry each time, and continued almost to the point of complete saturation. The waterglass used must be either the soda or the double waterglass, treated with as much liquor silicum as to render it perfectly clear.

Soda and double waterglass are preferable to potash waterglass, because they are absorbed more easily; they ought not to be used in a concentrated state, but diluted with equal parts of water, in order to ensure their penetrating to the wall. The thickness of the plaster will be different in different places, owing to unevenness in the wall; and since a thick layer requires more waterglass than a thin one, the latter will be saturated long before the other is, and it will be necessary to treat the thicker parts of the substratum separately with waterglass so long as it is absorbed, in order to render all parts equal.

When the lower ground has been thus prepared, the upper layer, which is to receive the picture, may be added soon after. To the careful preparation of this layer, I repeat it, the certainty of success and the facility of the execution are mainly due.

The thickness of this upper layer is about $\frac{1}{10}$th of an inch. In its composition it does not essentially differ from the lower one, and consists of lime mortar, which ought to be made with distilled or rain water and well-washed sand (calcareous or quartz sand), of a grain which does not exceed a certain size, and with not too much lime to prevent cracks and ensure complete absorption. It is better to run the sand through a sieve in order to obtain the right grain.

I am of opinion that artifically prepared calcareous sand, *i.e.*, sand obtained by grinding marble or dolomite, is preferable to the natural sand, because the latter consists of round, smooth grains, which do not set so well as the sharp-edged fresh grains of artificial sand. Very fine powder, on the other hand, which would set still better, is to be avoided, and should be removed by decantation or by means of a fine sieve, because it renders the mass too compact and less absorbent.

The conditions of the surface of the ground for painting is chiefly dependent upon the size of the grains of sand; the coarser the grain, the rougher the ground. This is to a certain degree rather advantageous than otherwise in painting, provided that water-colours adhere sufficiently until the waterglass be added. The surface ought to feel to the touch like a rasp, as Kaulbach expresses it. A difference must also be made according as the pictures are to be viewed at a great or a short distance; in the first case the sand used may be much coarser than in the second.

When this coat of mortar has become dry, it is sometimes rubbed over with a sharp sandstone or iron straight-edge, in order to remove the thin layer of carbonate of lime which has been formed during the process of drying, and which would prevent the waterglass from being absorbed,—and also to impart the required roughness to the surface.

I cannot however approve of this method, and I think it far better to destroy the calcareous incrustation by means of a simple chemical reaction, viz., by dilute phosphoric acid (1 part of concentrated acid to 6 parts of water). The acid is brushed over the surface by means of a sponge or brush. Phosphate of lime is formed, which binds well with the waterglass, so that the plaster does not suffer in the least; whereas, if mechanical friction is resorted to, there is a risk of detaching small pieces, and leaving small cavities which have to be filled in again.

When the ground has been thus prepared and well dried, it is impregnated with waterglass, in order to give it sufficient consistency, and to cement it well together with the substratum. It is advantageous to employ for this purpose double waterglass clarified with liquor silicum, and diluted with its equal bulk of water. It will be found sufficient to repeat this operation twice, after allowing some time for drying. Too much waterglass would only tend to close up the pores, which would throw considerable obstacles in the way of the painter. If too much should have been used, either the whole layer of plaster must be removed, or the oversight may be made good by waiting some time, till the further contraction of the waterglass renders the ground again sufficiently porous, or by applying heat, which is best done by burning alcohol on it.

After the upper ground has been thus prepared, either by rubbing or by the action of phosphoric acid, and cemented with double waterglass to which a little liquor silicum has been added, in such a manner that the waterglass is equally spread over the whole service, exhibiting a good and even absorption everywhere, painting *may be*, but *need not be* immediately proceeded with. Delay will only increase the capacity of absorption which the ground already possesses.

The artist has to observe no further precautions, and the necessary practice will soon be acquired by painting a few easel-pieces on such ground.

Artists who should, nevertheless, doubt the efficiency of the waterglass, and who should hesitate to undertake a larger work, will meet with the best advice at the hands of Herr von Kaulbach and M. Echter, who, I am sure, will be pleased to give the desired explanations and assistance.

The colours are ground with pure water and used by the artist upon the prepared surface, taking care to moisten the wall frequently with pure water, in order to displace the air from the pores and to ensure more completely the adherence of the colours. This syringing with water must be done with moderation, and only as often as necessary. Great care must be taken not to wet too much those parts which have been painted over, because, as M. Echter observes, the colours are liable to lose their freshness; it appears that the water washes the finest and least powerful particles of the colours up to the surface. This inconvenience is greatest in places which have to be painted over repeatedly, and have to be moistened each time. M. Echter, however, has found a remedy. He brushes away these fine particles of colour, after they have got dry and before the picture is fixed, with a very fine brush, and he thus restores the picture to its original freshness.

Nothing more remains but to fix the colours properly, to which end the fixing waterglass is more specially employed. It suffices to dilute it with half its volume of water.

The colours which adhere but slightly do not allow of the brush being used; and it is necessary to besprinkle the painting with waterglass in the form of a fine shower or mist, at first very carefully, so as not to displace the colours or to cause them to run one into another. Professor Schlotthauer, who has bestowed much time and labour upon stereochromic experiments, has invented a syringe for this purpose, which leaves nothing to be desired, and for which stereochromy is much indebted. The operation of alternate besprinkling and drying is continued until the colours adhere so firmly that they cannot be rubbed off with the finger. If white pocket-handkerchiefs, which are sometimes employed as tests, be smudged, it does not prove that the colours are not possessed of the desired durability, because rubbing with great force loosens grains of sand, the friction of which detaches

Digitized by Google

parts of the colour that indirectly smudge the pocket-handkerchief. The same is experienced in fresco-painting.

Experiments made with regard to the durability and solidity of colours have shown, that whilst some are sufficiently fixed, others are more or less loose, and soil the finger. This refers more especially to the so-called meagre colours, like black. These require more waterglass, which is added by means of a fine brush. Baron Kaulbach told me, however, a short time ago, that this occurs now but very rarely, since it can easily be guarded against by properly mixing the colours.

This is a general outline of the method by which Director von Kaulbach, assisted by the excellent painter M. Echter, has executed four large stereochromic paintings in the new museum at Berlin; and they all, especially the last, meet with unqualified approbation among all impartial artists and lovers of the art, as to the increased perfection in the technical execution, and they are generally acknowledged to be a real advance in the art of monumental painting.

Before proceeding further I have to make a few additional remarks. It was soon found that waterglass could not be employed stereochromy as oil in oil-painting, *i.e.* the colours could not be ground with waterglass before applying them. A very dilute solution even rendered the brushes soon stiff, and caused the colours to harden on the pallet. It remains to be seen, however, whether waterglass is to be rejected in all cases as an admixture to colours. There is no doubt that such a mixture cannot be dispensed with when damaged pictures have to be renovated, or when pictures which have been fixed are to be painted over in some parts, in order to restore harmony between these and the other portions of the picture. I am therefore of opinion that it may render good service in painting as an addition to many colours, especially to the meagre ones. I am not speaking now of the usual potash waterglass, which is inapplicable; but of that which has had liquor silicum and water added to it, and which is used for the fixing of pictures.

When the brush begins to become somewhat stiff, it has only to be put into pure water, and after a short time it will again be found fit for use, whilst another may be employed in the meantime. The brush must not be left exposed to the air before washing it, or else it would become quite stiff, and could no longer be softened in water. The hardening of the colours on the pallet may easily be prevented by adding, from time to time, a drop of water by means of a dropping-glass. It is well not to put too much colour upon the pallet.

These must be considered as a few hints only upon this subject; the trial of its applicability, however, must be left entirely to the artist.

I might mention here that Kaulbach executed the first picture by means of dilute waterglass, to which I had added a little caustic potash, upon a broad tile covered with a layer of plaster prepared with powdered marble, which served him as a ground for painting upon. The trial succeeded so well, that he felt at once strongly in favour of the new method of painting. This little picture exists still, and is well preserved, although it has been much knocked about; a second and much larger picture, similarly executed and well-finished, was destroyed by an accident. Soon after he expressed a wish to obtain a more tractable admixture to his colours than mere water, and I gave him a paste-like mass, such as is obtained by precipitating a dilute solution of alum with waterglass, and adding a little of the well-washed precipitate to the colours. A few trials were made, which for the most part succeeded well—some very well; but this also was not found to answer sufficiently; he thought it too tedious and inconvenient, and he convinced himself that no admixture is required when the grounds are rough, and that the colours adhere sufficiently with water alone.

Formerly, when potash waterglass was used for fixing the colours, it was often found to dry unevenly and to give a dirty appearance to the pictures, particularly when more waterglass was used than was absolutely necessary for the fixation. The "fixing waterglass" above described, has the advantage of allowing more freedom to the operator without any risk of staining the picture. An excess will only help to make the plaster-coat more durable. Should the surface be so much saturated with waterglass that an additional layer remains unabsorbed for a whole minute, it is better to blot off the excess with blotting-paper, as it might dry into greyish-white spots; but even these have been known to disappear spontaneously after a little time.

The painting is finished when the colours are fixed. It is well to wash the picture with spirits of wine after the lapse of a few days in order to remove any dirt or dust, as well as a little alkali which is set free; and at the end of a few more days it may be washed with pure water without any risk of damage to the colours or fear of injury from exposure to the rain. Spring-water, which is apt to deposit carbonate of lime, must not be used for washing.

If a painting is to be executed on the outside of a building, care must be taken not to expose it to a heavy rain before the colours are fixed, because an hour's exposure might destroy what required weeks to execute.

The finished picture, especially when it is exposed to the open air, ought to be carefully examined in the course of a few months or a year, to ascertain whether it has acquired any power of absorption. If so, it is evident that more fixing waterglass is required to fill up the pores caused by the gradual contraction of the original layer of waterglass. Although a second fixing operation is not absolutely necessary, it will improve the picture, for the more silica can be added to a stereochromic painting, the firmer and more durable will it become. My advice is, therefore, not to neglect the after-fixing of these paintings, especially of those on the outside of buildings, wherever it is feasible.

In the preceding lines I have spoken of the preparation which a fresh wall requires in order to render it fit for receiving a stereochromic painting, and I have now to answer the inquiry, which has frequently been addressed to me, whether old walls which are already covered with a layer of plaster can be used for stereochromic painting; to which question I can only give a conditionally affirmative reply. If the plaster has been rubbed with a rough sandstone and well smoothed, and if it then absorbs the colours well and is well cemented to the stones of the wall, thoroughly dry and free from efflorescent salts; or if, as it is said in common parlance, the wall is quite sound, there is no reason why it should not be used for painting with success, after it has been duly impregnated with waterglass. This is shown by the experiments which I made with Director von Zimmerman and the late Professor Krötz.

Our wish to try the execution of a stereochromic painting on the outside of an old building, on a wall which was much exposed to the action of the atmosphere, was met half way by M. Himbsel, who desired to have two images of saints executed at his country house, on the Lake of Starnberg, built about twenty years previously. The walls were found sound, the plaster firmly adhering to the stones (of which we convinced ourselves by striking the wall with a small hammer), and at the same time so little porous that it did not exhibit sufficient power of absorption, even after rubbing it with a very rough sandstone. We employed, therefore, phosphoric acid, diluted with ten parts of water, which was brushed twice over the wall. When dry, the wall was not very absorbent, yet sufficiently so to enable Von Zimmerman to begin his paintings without delay. The two pictures were executed without any difficulty, and satisfactorily fixed. The fixing was repeated after the lapse of a year. They are now five years old, and have remained quite intact ever since. I shall have to speak once more of these pictures.

The success which accompanied this first experiment naturally led to the idea that, perhaps, fresco-paintings could be converted into stereochromic paintings by a judicious use of waterglass, and thus rendered equally solid. I leave it undecided for the present, whether this could be done successfully, as I have not had an opportunity of trying experiments, although it must appear highly desirable to discover means of protecting fresco-paintings, which are still being executed in spite of the discovery of stereochromy.

For want of experience, I can only give my opinion as to what might be the best method of procedure.

The picture would first have to be washed with rain-water, slightly acidulated with pure vinegar, by way of besprinkling, in order to remove dust and dirt, principally however in order to remove the thin coating of carbonate of lime which has formed upon the surface, covering the colours and preventing the absorption of the waterglass. The besprinkling is repeated with pure water in order to remove the acetate of lime which has formed, and which would interfere with the subsequent action of the waterglass. Stronger acid would discolour the ultramarine and turn the chrome-red to chrome-yellow, and therefore must be avoided. Careful manipulation is required, even with the dilute acetic acid; and slight brushing with a sponge, soaked in the dilute acid, might sometimes conveniently be substituted for the

Digitized by Google

sprinkling; the acid must altogether be employed very sparingly, as the evolution of carbonic acid gas might otherwise loosen the colours and detach them from their underground. Nothing remains now to be done but to saturate the dry picture with fixing waterglass.

Our climate is, as is well known, not very favourable to fresco-painting. We have a proof of this in the deplorable state of a large and fine picture on the Isar gate at Munich, representing the Emperor Lewis, the Bavarian, after the battle of Ampfing, which was painted nearly twenty years ago, and which has already suffered so much that it is likely to be destroyed before long if it is not protected. And yet this picture is placed in a rather favourable situation, being painted on the east side of the gate; therefore not much exposed to bad weather, and sufficiently elevated to be protected from the moisture and saline matter of the soil. And is there no guarding against the destruction of this work of art? It is important to ascertain how far the decay has been allowed to go on,—whether it is superficial, or whether it goes to the very depth, whether fissures or cracks exist, and whether parts of the plaster have become detached. It must be left to the judgment of the renovator as to what course ought to be pursued with regard to the injured painting.

I can only say so much, that I know of no other remedy but the waterglass and the waterglass mortar; the first to fix the colours and the ground, the latter to fill up cracks and cavities, which then have to be painted over again by the artist. Although the picture may not be restored to its original perfection, it would nevertheless be protected from further decay, and saved from final destruction.

Stereochromy is but a child of late birth, and has yet to struggle for its existence, and it must not be supposed that it has already reached the highest degree of perfection. Once taken up by others, it will no doubt be improved, and promises many advantages which may have been overlooked.

The chief attention must be directed to the upper layer of plaster, or the painting ground; in this errors are easily committed, and have frequently been the source of failures.

I have therefore endeavoured to obtain a still better and surer method of preparing the painting ground, and I think I have succeeded in obtaining one which answers in every respect. I propose to prepare the upper coat of nothing but *waterglass cement, i. e.* a mortar in which the lime is replaced by waterglass. The sand to be mixed with it may either be powdered marble or dolomite,—or quartz-sand mixed with a little dry-slaked lime. [The addition of a little lime or white of zinc may also be of advantage when marble or dolomite are used, as it ensures a more perfect and powerful combination with the waterglass]. The mixture must be very intimately made. As to the proper proportions, it suffices to state that so much waterglass should be added as to give to the mass the consistency of ordinary mortar.

This cement is laid on equally thick over the first plaster coat, properly smoothed and allowed to dry. It possesses many considerable advantages over the lime mortar which is *subsequently* to be impregnated with waterglass. Its preparation is simple, and every experienced mason will easily render himself master of it; mistakes can scarcely be made, as the material once decided upon remains always the same. The waterglass is equally spread through the whole mass, so as to ensure equal cementation and silicatisation, which can scarcely be obtained when the waterglass is added at a later stage. During the repeated moistening of the picture no lime will be drawn to the surface and disturb the colours, because no soluble lime is left in the mass; moreover, no incrustation of carbonate of lime will ever form, and no rubbing with a stone will be required to render the surface absorbent. Lastly, the waterglass is here in immediate contact with the lower substratum, and ensures perfect adhesion to the wall, whereas the other method always leaves it uncertain whether the waterglass will penetrate the upper layer entirely and evenly.

This cement when dry becomes as hard as stone. At first it exhibits little or no power of absorption, which is easily accounted for, because all the pores are filled up with waterglass. It acquires, however, this property in a satisfactory degree by exposure to the air for a few days, especially when the air is warm and dry: but loses considerably in solidity by the contraction of the waterglass, and it becomes necessary to saturate it once or twice with waterglass diluted with half its volume of water, in order to impart to it the proper consistency. This must be done cautiously, so as not to stop up the pores by employing too much waterglass, which would obstruct the painting considerably. [The burning of spirits of wine on the surface would no doubt remedy the evil.]

If carbonate of soda effloresces on the surface, it is a sign that the plaster has set well. The efflorescence can easily be removed by means of a wet sponge, and the ground will then be found harder than before. Painting may now be proceeded with in the usual way.

M. Echter is at present engaged upon executing an easel-piece on a layer of waterglass cement, and the work promises well. He uses a plate of burned potter's clay, 3 ft. 4 in. high and 3 feet wide and half an inch thick. After saturating the plate with waterglass, a painting ground of one-tenth of an inch in thickness, consisting of waterglass cement, was laid on and well smoothed. Painting upon this ground proceeds so well, that M. Echter assures me he could not wish for a better one.

The waterglass cement employed for this plate was made of pulverised dolomite (from which the finest powder has been removed by means of a fine sieve) and a little dry-slaked lime, to which waterglass was added, so as to produce a mass of the usual plaster consistency. When dry, the plate was once more thoroughly impregnated with waterglass diluted with its own volume of water, &c. This picture has since been successfully finished, and is now in the possession of the King of Bavaria, and may be seen on a wall in the Royal Winter Garden. The artist has chosen for his subject the Madonna della Sedia, by Raphael.

Hydraulic lime has also been recommended as a suitable substratum for painting, because with a little waterglass it forms a mass of considerable hardness and great absorbing power, in which the lime sets sooner than in the hydraulic cement. According to the experiments of M. Feichtinger, one part of solid waterglass is sufficient for 15 parts of hydraulic lime; a larger amount would be injurious than otherwise. But since waterglass cement responds to every application to which it can possibly be put, and since we have it in our power to prepare it most successfully, I have abstained from experimenting further upon the hydraulic lime, especially as it seems to be difficult to obtain it of uniform composition, and the result will therefore always be doubtful. In my pamphlet, 'On Chalk and Cements,' I have already mentioned (p. 49) the service which waterglass is capable of rendering to hydraulic cement. "A very good method of protecting this or any other hydraulic cement from decay, and imparting to it considerable hardness, consists in the application of waterglass solution after the cement has slightly contracted. When the waterglass has been brushed over its surface, water has no longer any effect upon it. It becomes coated with a hard crust, behind which the lime and the cement quietly continue their mutual action. Small pieces put into a very dilute solution of waterglass became in two or three days so hard that they could no longer be scratched with the finger nail. The liquid, generally rendered cloudy by dissolved lime, remained perfectly clear. A method so inexpensive might therefore find more frequent application."

It has already been stated that stereochromy may be applied to a variety of substrata, and that even stereochromic easel pictures can be successfully executed. When moderately burned so as to ensure good absorption, plates of clay, vessels of potter's clay, stoves of clay, &c., after being sufficiently saturated with waterglass, can be painted upon directly or indirectly. It will, however, be well to give them first a slight coating of waterglass cement, which ensures more readily a flat and equally coarse surface suitable for painting. Easel pieces of considerable size may be painted upon plates of clay. The only limit to their size is the difficulty of managing plates of great weight. The plates should not be thicker than three-fourths of an inch, and not too much burned, so that they may absorb well. Their surface should be flat, but not smooth. Frequent saturation with double waterglass, diluted with half its volume of water, imparts to them a solidity such as strong burning could not do. Should they lose their absorbing power by the addition of too much waterglass, they have only to be warmed for some time, *e.g.*, by burning spirits of wine on them.

If it is required immediately to paint upon such a ground, it is well to add a little fixing waterglass to the colours, especially to the meagre ones. The further treatment is self-evident. Objects made of burnt clay, such as figures, ornaments, vases, goblets, &c. can likewise be painted, and would gain considerably in beauty and durability. Attention would, however, have to be paid to the quality of clay which is used for such vessels.

Digitized by Google

I would draw attention to an application which might be made of waterglass, viz., to impart to our stoves, which are generally made of burnt clay (Dutch tiles), a more agreeable appearance, thus offering to art a means of embellishing our rooms, and awaking the sense for the beautiful.

In order to convince myself of its feasibility, I had a tile taken out of the stove in my laboratory, and a new one of the same clay put in, which was first sufficiently saturated with waterglass and then painted with band-like streaks of various colours mixed with a little waterglass, and finally fixed. After the stove had been heated several times, the colours began to loosen, and they had again to be fixed; and this fixing process had to be repeated several times.

It is evident that heat increases the contraction of the waterglass, and I should have done better by saturating the tile repeatedly with waterglass and heating it in order to impart to it the greatest possible quantity of waterglass; and I would advise complete saturation in any fresh experiments which may be made. The colours stood very well for two winters, in spite of being daily exposed to a strong heat; and they adhered so firmly that they could only be detached with great difficulty. The stoker however made an end to all further observations, by accidentally breaking the tile in pieces, upon which the colours are still preserved undimmed.

Herr von Dyk, director of the telegraphic office at Munich, has shown that cast-iron may successfully be painted stereochromically. At the instance of Prof. Pettenkoffer he ordered the cast-iron stoves in his offices to be painted on the flat parts with so-called caput mortuum, and on the raised parts (such as frames and decorations) with zinc white. The paint has stood well up to the present time. Herr von Dyk made the interesting observation, that if the colour is applied while the iron is cold, it falls off when the stove is heated, but that it adheres well if applied while the iron feels warm to the touch. The cause of this difference lies no doubt in the pores of the iron being somewhat more open at a slightly raised temperature, the air being slightly rarefied or partly displaced, so that the waterglass penetrates better. This leads me to draw particular attention to the temperature at which the fixing of the painting ground and of the stereochromic picture is performed, especially to the temperature which the waterglass itself possesses.

It is very important that the waterglass should soak in evenly and deeply, in order to ensure everywhere equal and strong cementation. For this reason the waterglass ought to be diluted with water. Like other fluids it is rendered much more liquid when heated—say to between 100° and 120°—and penetrates therefore more readily into any porous mass, by displacing more easily the air than it would do at the common temperature, and renders it much more suitable for fixing colours upon porous objects. This action of the heat will be the more perceptible if the objects themselves as well as the waterglass are slightly heated, so that with care and attention a solidity and durability may be obtained such as mosaic works only possess.

If a syringe be employed for fixing the waterglass, it is most conveniently warmed by plunging it into warm water. Mural surfaces which have to be fixed with waterglass are best heated by burning alcohol on them, which process however can only be resorted to when the colours, which adhere but loosely, have once been fixed with waterglass in the usual way. The rooms in which the fixing process has to be carried on ought evidently to be kept warm during this operation.

Plates of lithographic limestone may likewise be used as a ground for stereochromic pictures; the first trials in stereochromic painting were in fact confined to such stones. They require however to be coated with a thin layer of waterglass cement mixed with somewhat coarse sand, in order to ensure the adhesion of the painting ground. When the cement is quite dry the upper coat is put on, and painting may be proceeded with. If the lithographic stone is treated with phosphoric acid it takes the colours well which are mixed with waterglass; it is therefore probable that in that state they may serve for stereochromic painting without any further preparation.

There is no doubt that plates of clay-slate can be painted upon stereochromically after having received the proper preparation. This material has the advantage over clay or limestone plates that it is less brittle, and need not therefore be so thick. I have as yet made no experiments with it. Porous sandstone and porous limestone, when well saturated with waterglass, must likewise furnish a good ground for stereochromic painting either directly or indirectly: there is at least no reason why they should not.*

No stereochromic painting has as yet been directly executed upon wood. The waterglass mixed with colours has however been successfully employed for staining wood. When wood has been properly saturated with waterglass, the waterglass cement adheres well to it, and upon a thin layer of this cement a picture might of course be executed. In many instances the method may prove very useful.

It remains doubtful at present whether a transparent stereochromic painting can be executed upon glass. There is however no difficuly in painting indirectly upon glass, if ever it should be thought advantageous, since waterglass cement upon which the painting would have to be done binds exceedingly well with glass.

It would be very desirable to employ such a light and flexible material as canvas as a ground for stereochromic painting, because easel pictures of some extent, such as altar-pieces, could then readily be painted. Several experiments have been made, which have not yet led to satisfactory results: they are however being continued.

I have to make a few more remarks with regard to the colours which may be employed in stereochromy. Their number is so great that the new kind of painting is not restricted in their use. M. Ch. Buchner, manufacturer of chemical products at Munich (Karlstrasse, No. 40), constantly keeps a complete assortment of them in store. They are

1. Munich white.
2. Munich black.
3. Munich brown.
4. Chrome green.
5. Cobalt green, light and dark.
6. Chrome red.
7. Oxide of iron, bright red, reddish brown, violet and brown.
8. Cadmium yellow, light & dark.
9. Chrome yellow.
10. Ultramarine.
11. Dark ochre,—the same burnt.
12. Flesh ochre.
13. Gold ochre,—ditto burnt.
14. Terra di Siena.
15. Umber,—ditto burnt.

No organic colour, such as lake, is admissible, because it will sooner or later be found to fade. Vermillion must also be rejected, because, when exposed to the light, it darkens and ultimately turns black. The colours ought to be ground as finely as possible, because they are rendered thereby more manageable and more adhesive. Chrome red alone forms an exception, because long-continued grinding turns it yellow. Cobalt blue shows a brighter blue after fixing, and light ochre becomes darker. These two colours cannot therefore be recommended for this kind of painting.

It must be remarked that the fixing process produces slight changes in *all* the colours of the painting, which appears afterwards of a somewhat darker or more sombre hue; but after some time this effect disappears again.

The colours ought to be as pure as possible; they ought especially not to contain anything which reacts upon the waterglass and produces a decomposition, or causes it to coagulate, such as gypsum or sulphuric acid, which are frequently met with in red oxide of iron (kolkothar, caput mortuum), and in yellow ochre.

I cannot close this article without saying a few words with regard to the peculiarities, the convenience and advantage which this method of painting promises, in comparison with fresco painting, and the so-called *encaustic*.

Its peculiarity consists in an entirely new vehicle, differing from those employed in every other method of painting, so that stereochromy must be looked upon *as quite a new method of painting*. The excellence of this method depends on the substratum of the picture, which enables it to resist the action of every climate, as well as the destructive influences of smoke, acid vapours, quick changes of temperature, hail, &c., which would destroy frescoes. I have therefore called it *stereochromy*.

The new vehicle holds the painting ground and the colours, as it were, fused together, silicated or petrified, forming the material distinction of this kind of painting, and rendering it far superior to fresco painting with its ordinary ground of lime-mortar.

The durability of fresco paintings depends chiefly upon this mortar, even more than upon the skill of the painter, who is usually blamed when his work does not succeed, or lasts only a

* Paintings upon stone plates can be placed in walls in such a manner as to make them appear to form part of the wall. Once well fitted in, they are ensured against all accidents, and yet may easily be removed if necessary,

Digitized by Google

short time. The ruin of a fresco painting is, in my opinion, caused by errors committed in the preparation of the mortar; the only error almost which the painter can commit is the choice of colours, which fade or become discoloured in the course of time. Cornelius, when executing the frescoes in the Glyptothek at Munich, met with several difficulties of this kind, and he was accused of not understanding fresco painting. When I was called upon to report upon the case, I found that the plaster was rotten, and contained much sulphate of magnesia or bitter salt. I ordered this ground to be entirely removed and to be replaced by a new one, prepared with washed sand and distilled water. No further complaint was made, and the paintings have stood very well. Much depends also upon the lime used in the mortar. If slaked and kept moist for some time, it answers better than freshly slaked lime; if poor it acts better than rich; lime containing magnesia, oxide of iron, or manganese, is better than pure lime.

Encaustic painting has two enemies; the mortar ground and the organic materials used for painting, which are subjected to the natural laws of decay and decomposition.

In more southern countries, as in Italy, fresco paintings withstand, no doubt, longer the ravages of time than in northern climates; they are, however, not quite exempt from destruction, as is proved by Raphael's frescoes in the Loggie of the Vatican, which are said to have suffered considerably; and it has been found necessary to take precautions to prevent the further spreading of the destructive action.

In order to test the advantages of stereochromy, proof plates were submitted to the roughest treatment; they were exposed for weeks to rain and frost; the ice which had formed upon them was allowed to thaw in a warm room, and this freezing and thawing process was repeated without in the slightest degree damaging the plates, whilst fresco paintings treated in the same manner became quite friable and crumbled to pieces.

A small stereochromic picture was exposed on the roof of the Royal Museum at Berlin near the chimney to the action of wet and cold, smoke and soot, for a whole severe winter. When taken down in spring, it certainly looked as if it had been completely spoiled; but upon its being washed with spirits of wine, it was found to be as fresh as ever it had been. A small picture (two peacocks) on the west side of Herr von Kaulbach's atelier, close to the ground, has been preserved well, although the ground is thoroughly damp, and covered with shrubs in summer. It deserves to be noticed, that the damp and the efflorescence of the wall during this rather long period of time, had scarcely any damaging effect upon the picture.

A further proof of the durability of stereochromic paintings will be found in the two pictures at the country-house of M. Himbsel, on the Lake of Starnberg, to which I have already referred. They are now six years old, and are still as fresh and unchanged as if they had just come from the hand of the artist, in spite of storm and weather, which often sweeps from the west over the lake close by, and dashes the rain upon the walls with such force, that it runs down in streams, forming sometimes crusts of ice in winter.

Stereochromy offers considerable advantage to the artist; painting is quite in his power, as well as the material, whilst fresco painting makes him a slave of the latter. He is enabled to interrupt his work and continue it again after a shorter or longer time; he can retouch his painting before fixing it, as often as he thinks it desirable. The finest colouring, the slightest touch of light and shade, the harmony of colours, and consequently the greatest perfection of a painting, are in his power.

Stereochromy possesses that advantage which fresco painting also has over oil painting, that the colours are not shining, and that the observer can get a full view of a picture in whatever position he may be.

YIEWSLEY NEW CHURCH, MIDDLESEX.

THE new church just completed at Yiewsley, in the parish of Hillingdon, was consecrated by the Bishop of London on the 6th ult. Its situation, within a quarter of a mile of the railway station at West Drayton, renders it a conspicuous object, though not important in point of size. It consists of simply a nave and chancel, with south porch, and a vestry on the north side adjoining the chancel. There is no steeple, but a plain stone bell-turret rises from the east gable of the nave. The walling is built of local bricks and tiles, the facework being of yellow malm paviors, and the banding and diaper patterns being of red brick. Stone is but sparingly used, and in certain portions of the dressings only. The side windows are coupled lancets, wholly of brick, and each has a gabled roof, which runs back into that of the church. The roof is of unusually lofty pitch, and is of course open to the rafters internally. The chancel terminates semicircularly, and is somewhat richer in its treatment, though here also brick is the chief material. On the summit of the apse is a handsome metal cross.

The whole of the fittings, including the pulpit, desk, and altar-rail, are of pitch pine, which has been carefully selected: they are varnished, and have a remarkably good appearance. The passages are paved with red and blue Staffordshire tiles. The font is of Caen stone, and was the gift of the builders, Messrs. Fassnidge and Son, of Uxbridge. The west window (of four lights) is filled with Laver's quarries,—the east window with stained glass, the gift of the vicar and his sister-in-law. The accommodation is for 300 adults and 50 children; and the amount of the contract was £1400. The architect was Mr. Scott, of London. The heating is by a hot-water apparatus, which was supplied and laid down by the contractors at a cost not exceeding £50.

HIGH SPEED STEAM NAVIGATION.

Mr. Robert Armstrong, naval architect, of Poplar, has just published his views on what he terms 'High Speed Steam Navigation and Steamship Perfection.'* Mr. Armstrong has on several occasions maintained opinions at variance with the ordinary formulæ of mechanicians and naval architects, and he considers himself to have been somewhat unfairly used by the Institution of Civil Engineers in the treatment of papers submitted by him for their consideration; hence he has determined to vindicate his opinions in print. Without at the present time expressing an opinion on the subject, we extract from this publication Mr. Armstrong's "Address to the Scientific World," which serves as the introduction to his pamphlet.

"The immediate object of this pamphlet is to call the attention of scientific men to a reconsideration of the principles of mechanics; to define perfection in machines; and to reduce naval architecture to an exact science. For it may truly be said, we are still experimenting in many departments of mechanics that ought to be susceptible of mathematical accuracy, if those principles were clearly defined.

"No better proof can be exhibited of the total want of a correct application of the principles of applied mechanics to the sciences in connection with steam navigation by our naval architects and marine engineers, than by stating that one man alone has cost this country nearly four millions of pounds in experimenting upon the forms of ships, without establishing a single useful result. And the continually repeated proposition of the following subject by the Institution of Civil Engineers, viz. 'On the circumstances which appear to limit the maintenance of higher speeds than are now attained by our steamships in deep sea navigation; and an inquiry into the circumstances which have hitherto prevented the asserted high speeds of steam navigation on the American rivers from being arrived at in England,' is a further proof of our deficiency of any established rules essential to the perfection of naval science, and the want of correct data amongst practical men, by an institution claiming to be the highest mechanical tribunal in the world.

"It was in answer to the above proposition that two reports on the trial trips of the vessels belonging to the Peninsular and Oriental Steam Navigation Company were sent to that Institution, as a reply to my former opponents, and for discussion in the session of 1857-58. The production of these reports was refused, and since that time the proposition has been removed from the subjects of the session of 1858-59. The refusal of my papers, coupled with the rejection of the above subject by the Institution of Civil Engineers, is the primary cause of my publishing this pamphlet, to assert my claim as the solver of this important problem, and to be considered the first to point out the correct application of the principles of mechanics to steam navigation, the railway, and wherever the steam engine is required to produce mechanical effect (foot-pounds of work, duty) the great end of its application; for I firmly believe five millions are annually wasted in the consumption of fuel, and in the wear and tear of machinery, by the mechanical world, through their ignorance of the fundamental principles of mechanics.

"Nor do I think it at all creditable to the Professors of Mechanics in our Universities not to point out the incorrectness of the present rule for

* 'High Speed Steam Navigation and Steamship Perfection, &c. A Proposition for the solution of the Scientific World, and for the consideration of the British Admiralty.' By Robt. Armstrong.—London: Spon, Bucklersbury.

Digitized by Google

calculating indicated horse power that embodies an assumption of Kepler's, the error of which was pointed out by Beneditti nearly three centuries ago, an epoch previous to the establishment of the laws of motion, viz. that of supposing that as a force is requisite to move a body, so a perpetual supply of force is requisite to keep it in motion. Now as the theory here advocated by me cannot possibly be protected by a patent, I have availed myself of this opportunity of laying before the scientific world generally my conception of the principles of mechanics, and of calling the attention of the British Admiralty, as the greatest employers of the steam engine in the world, to the many important subjects which this pamphlet embraces; and of asking, at the same time, some compensation from the government for having worked out correct principles, and their method of application to steam navigation.

"The principles offered for criticism may be generalised as follows. It is asserted by naval architects and marine engineers, that theoretical science lends but feeble aid to naval architecture; while I assert the known principles of mechanics contain all that is requisite to render their application simple and easy. To be brief, the error of the mechanical world consists in believing that the mechanical effect of force is a variable quantity, that it can be increased *ad libitum*, according to the ingenuity of the operator; hence their present rule for calculating indicated horse power, viz. mechanical effect $\propto$ force and velocity, is essentially incorrect, as I shall presently show; and in opposition to which I assert—1st. That the fundamental principle of applied mechanics is the *conservation of the mechanical effect of force.* 2nd. That the mechanical effect of force is in proportion to the force and *time*, and not in proportion to the force and its *velocity.* 3rd. That the mechanical effect of force *cannot be increased by any mechanical appliance*, and that the pressure at rest, or on the ends of the cylinder (whatever be the velocity of the piston) is properly the power of the steam engine. Consequently, in applied mechanics the formula, force lbs. = retarding pressure × velocity, feet per second, contains all the elements necessary for any dynamical or hydrodynamical operation, when a uniform force, such as a pressure of steam, is employed.

"This reason implies that there is a limit to the amount of the mechanical effect of force. To ascertain that limit I solicit the assistance of the physical world for the solution of the two following propositions, after the manner of the philosophers of the two last centuries. First, What is the *maximum theoretical amount of mechanical effect* that can be obtained by any mechanical appliance from a given force in a unit of time? and, second, What is the minimum length of space that a uniform force—a pressure of steam, for instance—requires to act in to produce its greatest mechanical effect? The former proposition is similar to prop. 21, section 6, 'Atwood,' p. 248.

"The object of these propositions is for theory to define to the mechanic the all-important desideratum,—what may be termed perfection in any machine, whether it be a steam vessel, steam engine, pump or propeller? to prevent the continual experimenting on those machines, and more especially the profitless employment of the 'faculty of mechanical invention,' so common in this country, pointed out by Mr. J. S. Russell, after the reading of a paper by Mr. McGregor, on 'The Paddle Wheel and Screw Propeller, from the earliest times;' for it may safely be asserted, until the maximum effect of force is defined and obtained in practice, there will always be employment for that faculty, so abundant in this country.

"In my second report I have shown that a force is only capable of raising an equal retarding pressure through *one English foot in a second of time;* therefore, granting the average pressure in the cylinders of a steam engine as the force exerted (which I question), we may safely conclude that no more invention on the subject of propellers, or forms of vessels, is necessary, as 50 per cent. of the tabulated vessels, hull, engine, and propeller combined, have accomplished this proposed amount of the mechanical effect of force, or all that I deem the laws of mechanics will admit of. And as a proof that I am not alone in advocating these principles, a quotation from Whewell's 'History of the Inductive Sciences,' vol. ii., p. 440, will be sufficient. 'Among these I may mention a new abstract term, introduced because a general mechanical principle can be explained by it, which has lately been much employed by the mathematical engineers of France, MM. Poncelet, Navier, Morin, and others. The abstract term is *travail*, which has been translated *labouring force*, and the principle which gives it its value, and makes it useful in the solution of problems, is this—that the work done (in overcoming resistance, or producing any other effect) is equal to the *labouring force*, by whatever contrivances the force be employed. This is not a new principle, being in fact mathematically equivalent to the conservation of *vis viva;* but it has been employed by the mathematicians of whom I have spoken, with a fertility and simplicity which make it the mark of a new school of the mechanics of engineering.'

"In proving the truth of the theory of the conservation of the mechanical effect of force, by the actual performance of steam vessels, I have adopted the same method of analysis as at present practised by the engineer and naval architect, which may be thus defined. Having the actual velocity of the vessel, the area of the midship section, and the indicated horse-power given—to find the supposed value of the combined coefficient of form (K), and friction (F) on the sides of the vessel—viz., I.H.P. × $(KF) = V^3 \times$ midship section. These co-efficients are given in the vessels tabulated in the columns under $\frac{V^3 \times \text{midship section.}}{\text{I.H.P.}}$ In my analysis the velocity of the piston (V) is added to the other unknown terms K and F, or force × $(VKF) = V^3$ midship section. Consequently the column 'ratio of forces,' represents the combined value of the velocity of piston, form, and friction; the conclusion being, that if those ratios varied in the proportion of the velocity of the piston (which they do not), then the present rule for calculating indicated horse power would be correct, as the forms of vessels selected in the navy are nearly identical.

"Now if this mode of analysis, which I submit for the criticism of the mathematician, is correct, there cannot be a doubt that the theory here advocated is the correct reading of the principles of applied mechanics.

"Suppose the amount of mechanical effect in any of the tabulated vessels is required (still granting the average pressure in the cylinders the force exerted by the engine), then the column, 'ratio of forces,' represents *in lbs.* the amount of retarding pressure raised one foot high in one second by the force of one pound in the cylinder. Thus the useful effect produced by the Miranda is 1·14 foot lb., Pioneer 1·02, Flying Fish 1·04, and the Victor 1·06.

	Miranda.	No. 1 Experiment. Pioneer.	No. 5 Experiment. Flying Fish.	Victor.
Tonnage B.M.	1039	868	868	851
Length	196	200	200	200
Breadth	34 0	30 4	30 4	30 2
Displacement	1350	1050	1056	1019
Mid-section	336	277	273	264
Ratio of length to breadth	5·77	6·59	6·59	6·63
Tons displacement to one square foot of midship section	4·02	3·82	3·79	3·86
$\frac{V^3 \times \text{mid-section}}{\text{I.H.P.}} =$	680	336	443	351
$\frac{V^3 \times D\frac{3}{4}}{\text{I.H.P.}} =$	247	127	167	135
Velocity of piston	3·56	6·83	5·12	6·83
Pressure on cylinders	94720	95988	94305	93886
A × Vel²	109372	99645	99166	99792
Indicated horse power	613	1192	877	1165
Velocity in knots	10·75	11·36	11·20	11·58
Velocity in feet per second	18·08	19·09	18·92	19·43
$\frac{\sqrt{\text{Force} \times 1}}{\text{Mid-section}} =$	16·79	18·73	18·43	18·84
Ratio of speeds	1·07	1·01	1·02	1·03
Ratio of forces	1·14	1·02	1·04	1·06
Length of screw	1 11	3 0	3 0	3 0
Diameter of screw	12 0	11 0	13 2	11 0
Ratio of pitch to diameter	·96	1·86	1·52	1·86
Revolution of screw	87	82	68	82
Nominal H.P.	250	350	350	350
Diameter of cylinders	56¾	55	58	55
Length of stroke	3 9	2 6	2 3	2 6
Revolution of engines	28	82	68	82
Draught of water forward	12 3	10 6	10 8	10 3
Draught of water aft	12 6	12 0	12 11	12 0
Immersion of centre of screw	5 3	5 2	5 6	5 3

"Again, if it were required to find the cause of variation of the co-efficients of various vessels by the well-known formula

$$K = \frac{V^3 \times \text{mid-section}}{\text{I.H.P.}} \quad \text{or} \quad K = \frac{V^3 \times D\frac{3}{4}}{\text{I.H.P.}}$$

I would not require a better proof of the truth of my 'peculiar views' than their employment; where it will be observed in the four selected vessels, that the co-efficients vary exactly in the proportion of the velocity of the piston; or, if they are to be accepted as the efficiency of these vessels, it may truly be asserted that the sciences in connexion with steam navigation are retrograding. These four vessels, viz., Miranda, Pioneer, Flying Fish, and Victor, the three latter built expressly for speed, are selected for the trial trips, published by the Admiralty, in 1856. They present a good comparison in the Miranda, by which the practice of engineering ten years ago can be compared with the more modern—direct action—and increasing the velocity of the piston, to add to the power of the steam engine. First, if we examine the data connected with the forms of these vessels, in the ratio of length to breadth, and displacement to midship section, it may be asserted (if the sharp water-line theory is an advantage) that the Miranda is the worst vessel for speed; then in examining the cause of the slight variation in the velocity, we find the Miranda has the greatest immersed midship section;

Digitized by Google

and further, as the speed increases in the others, the section in the line of motion decreases, and in proportion to the velocity; consequently, these vessels present an equal comparison in speed and midship section for the testing of a principle.

"Let me now invite the attention of the Admiralty, or the engineers of these vessels, to the data connected with the engines; the question being, Is the force, or 'the force and space passed over by the piston,' the power of the steam engine? If the velocity of those vessels for a comparison are equal, *surely the propelling power ought to be in the same proportion.* For the proof, examine the data, and we shall find the pressure on the cylinders does not *vary* 2 *per cent.*, whilst what the mechanical world calls power *varies* 100 *per cent.*; or in other words, the consumption of fuel, and the wear and tear of the engines in the Pioneer and Victor (the modern practice) is double that in the Miranda, without any increase of mechanical effect or speed of vessel. These figures suggest an important problem for the consideration of the Admiralty, viz., If the velocity of piston in the Pioneer, 6·83, *can be reduced to* 3·56 *in the Miranda, by gearing, with an equal efficiency of speed,* how much further can it be reduced by an increase in the multiple of gearing, without diminishing the efficiency of the force employed? And as the probabilities are great that our steam navy will be considerably increased, it behoves all that it be done as economically as possible; for this reason I would invite attention to the nominal horse power, when it will be found that the Miranda's engines, at £60 per horse, cost 25 per cent. or £6000 less than the others. I therefore ask the advocates of the modern practice of engineering, to point out the advantages of such increased outlay.

"Lastly, a comparison of the column 'pressure in cylinders,' with that requisite for a plane $F = AV^2$ is quite sufficient to prove the fallacy of the oft-repeated assertion of Mr. John Scott Russell, Mr. Moy, and other advocates of the wave or sharp water-line theory, viz., that the force necessary to propel a vessel has been decreased by such appliance to one-sixth of that produced by Col. Beaufoy's formula, it may be advanced that the ratio of the velocity of the piston to the speed of vessel is in that proportion; but a perusal of that column in the tabulated lists will be amply sufficient to point out the fallacy of such reasoning. As a means by which the important *problem of perfection* can be determined, I have produced the valuable data published by the steam department of the Admiralty, in 1850 and 1856, the latter tabulated according to the various degrees of efficiency (the figure before the vessel representing the number of experiment in that list) as the most reliable, in preference to data from private sources; which ought to be sufficient when a comparison is made with a plane—consequently, in the discussion which I invite upon this subject, private data cannot be admitted until the inaccuracy of the Admiralty reports is proved, which, I venture to say, contain every requirement in extremes of form and velocity of piston, for an investigation of the sciences connected with steam navigation.

"It would be useless to attempt to arrive at the real cause of variation in the amounts of mechanical effect (ratio of forces), having only the average pressure in the cylinders given. For this reason, and for a complete investigation of the subject, I beg to suggest to the Admiralty to give the maximum pressure in the cylinders, and at 6 or 8 points in the stroke of the engine; also, the pressure of steam in the steam pipe as near to the cylinders as possible, as I cannot think the indicator on the ends of the cylinder, especially in such rapid-working engines as in the second experiment of the Forth, *where* 3·8 *strokes of the engine are made in one second,* would have time to show the maximum pressure. But as far as the truth of my reading of mechanics is concerned, it is amply confirmed by engines, whether direct or geared, some as high as 5 to 1 in the multiple of gearing. Nor do I think the Fairy, Dauntless, Desperate, and others, by not producing the amount of mechanical effect defined, any proof that it is too great, but would rather attribute it to the propeller not producing the mechanical effect in the direction required; consequently, I have not the slightest doubt that such vessels have the greatest tremulous motion at the stern (a supposition worthy of investigation.)

"To the British Admiralty, and all employers of mechanical appliances, the advantages of defining perfection would be abundant, as having a tendency to defeat the practice of quackery, or the pretensions of the charlatan, in whatever form it may appear, whether in the parobolic water-line, in vessels,—in the numerous patented propellers,—or in other mechanical appliances that are merely modifications of existing plans. Apropos of the pump controversy, the decision would be thus—if each pump raised the defined amount of mechanical effect with an equal force, the question would be simply the prime cost, and the least wear and tear of the parts in a given time.

"With respect to the vessels composing our navy, in *form of hull,* they are perfection; the same may be said of the common screw propeller once employed in the Rattler, now exhibiting at Kensington Museum. Therefore the problem for the mechanical world is—to produce the maximum mechanical effect of force defined as perfection, at the least cost in the consumption of fuel, and in the wear and tear of machinery, a desideratum which, I venture to predict, will soon be obtained, when the last remaining problem of terrestrial mechanics is solved."

THE MAIN DRAINAGE OF LONDON.

Up to the present time, the object of all London drainage has been to make the Thames the great main sewer of the metropolis, an object which we shall see has been realised to the very fullest extent. All the sewers in London on both sides of the river run due north and south, all discharging themselves into the Thames, all within a length of some five or six miles. At the first glance this arrangement is bad enough, but it becomes worse still when we come to examine how it works. On both sides of the river the banks are scarcely above high-water mark, while the average level of the ground immediately behind these banks is much below it, half Lambeth, Bermondsey, and Rotherhithe being six feet below high-water level. As a natural consequence of this, the sewers are lower still, and their outlets are so completely tide-locked that it is only at dead low water that they can empty themselves at all. Thus for twelve hours the sewage on both sides of London is pent up, and gives off its miasma, through the elaborate system of sewers and drains, into every street and house.

The magnitude and importance of this danger have at last not only been seen, but means adopted to put an end to it for ever. Mr. Bazalgette, the chief engineer of the Board of Works, has fought long and arduously for his drainage system, and, like all the struggles of earnest and clever men, the fight, though hard, has been a successful one at last. His main drainage scheme has been adopted, and is now being carried out, and in a comparatively short time for such a gigantic work the Thames will be pure, and London at last effectually drained. As may easily be imagined in a work of such magnitude—a work which will take five years to execute, and cost, when all is told, four millions sterling, it is impossible in an article like the present to give more than a brief outline of the general plan for the north side. We shall reserve for another occasion a description of the drainage intended for the south side of the metropolis, and notice some curious details connected with the works as the works themselves proceed.

The intercepting main drainage scheme for the north may be best described as consisting of three gigantic main tunnels or sewers, which extend across London from Kilburn and Hampstead to Barking, and which, cutting all the existing sewers at right angles, intercept their flow to the Thames, and carry every gallon of London sewage under certain conditions into the Thames below Barking. Three of these main sewers or tunnels will be for the north side, and three for the south. With the latter however at present we have nothing to do. Those on the north are called the high level, the middle level, and the low level sewers.

The first-named, which is now in course of rapid construction, is about 8 miles in length, and consists like all the others of a double-barrelled sewer, if we may so term it; each barrel or sewer at its rise (in Gospel Oak fields, Hampstead) being 4ft. 6in. in diameter, and thence gradually increasing in circumference as the waters of the sewers it intercepts require a wider course to 5 feet, 6 feet, 7 feet, 10 ft. 6 in., 11 ft. 6 in., and at its termination near Lea river to 12 ft. 6 in. in diameter. This monster sewer drains an area of 14 square miles, and its rate of inclination from its source to its outfall varies from 20 feet per mile in the smallest parts to 3 feet per mile in the widest. Its course is from Hampstead and Highgate through the fields into Tufnell-park-road, and thence (receiving the sewage of the Edgware-road and Regent's-park) to Holloway, whence it passes under the Great Northern Railway and New River Cut, on to High-street, Stoke Newington, to Abney-park Cemetery, along the Rectory and Amherst roads to Church-street, Hackney. Thence it curves under the East and West India Dock Railway, along Albion-road and West-street, through the Victoria-park and under Sir George Duckett's canal, where it is kept to such a level as enables it to pass on an embankment and viaduct over the Lea river. The average depth of the whole is from 20 to 26 feet below the ground.

The middle level sewer is taken still lower, at from 30 to 36 feet down. The length of this main line will be about 14 miles, since it extends from above Kilburn to Lea river, and intercepts the sewage from the Thames over an area of more than 16 square miles. This drains all Acton, Kilburn, Notting-hill, Bayswater, Oxford-street, Regent-street, Holborn, Clerkenwell, St. Luke's, Shoreditch, and Bethnal-green, and so on as with the high level, over the Lea at Old Ford.

The low level sewer will be taken at a much greater depth,

Digitized by Google

about 40 feet, and all must be tunnelled. This will drain an area of 11 square miles, from Grosvenor-row, Queen's-row, Chelsea; along Parliament-street and Whitehall; Bridge-street, Blackfriars; Cannon-street, Tower-hill, through the Mint, Commercial-road, and Limehouse, under the river Lea near the Three Mills-bridge, to a pumping station where its waters will be lifted to the two higher level sewers we have described at Old Ford, and thence carried away by its own gravity to the reservoir below Barking. While these high, middle and low level sewers are being completed to Old Ford over the Lea, a contract will be entered into for the continuation of three 12-feet diameter drains, or rather tunnels from that spot across the marshes to about a mile below Barking, where the reservoir is to be formed. This reservoir will be a mile and a-half long by about 100 feet wide and 21 feet deep, and capable of containing no less than 7,000,000 cubic feet, or double the average amount of sewage which accumulates in the eight hours in which the reservoir outlet remains closed from the river. While in this reservoir the whole body of sewage will be deodorised, and experiments are now making as to the cheapest and most efficient agent for this purpose, though as yet nothing better than lime has been found. From the bottom of the reservoir in three or four places immense outfall pipes pass along the bed of the river to the very centre of the stream. When the sewage has been thoroughly deodorised, these outfall pipes would be opened at high water, and the whole mass let off into the Thames at a depth of 60 feet below its surface. Mixed with such an immense body of water and previously deodorised, the sewage of London may then, for the first time, be said to be comparatively harmless for evil. It will take two hours to empty the reservoir, and as the outlet commences at high tide, the whole mass will be completely swept away into salt water by the time the tide has ebbed. The reason for having the reservoir of such little width and immense length is to enable it to be covered over with brick arches and earth, so that none of the gases can escape. A considerable number of persons hold that the sewage of London possesses a considerable market value as liquid manure. Without at all discussing this question, on which so many discordant opinions exist, we may say that arrangements are about being entered into between the Board of Works and a company which proposes to bring the question to a practical solution, and to apply the sewage as manure for a certain time, and under certain conditions. This attempt to utilise the sewage will be made on a large scale and after the best plans, so that, one way or the other, the question will be set at rest for ever.

Such is a general outline of the intercepting scheme of main drainage for the north of London. The high level drain contract has been taken by Mr. Moxon. The most important portions of this great undertaking are now being carried on near the Lea river and Victoria-park, where the excavations, tunnellings, and buildings are proceeding with astonishing quickness, and with a solidity of workmanship that is almost wonderful. Both the high and middle level services have a special apparatus for diverting the "storm water" caused by violent floods of rain into the river Lea, while the sewage proper is carried down as we have shown, below Barking. For this purpose the high level sewer—and the plan will be the same in the middle level—instead of following the inclination of the ground from Victoria-park to the river Lea, is taken on a gradually rising embankment over the Lea towards the Thames. At this part, for 1300 feet of its length, the sewers are quadrupled—that is, instead of being only two sewers of 12 ft. 6 in. in diameter, they consist of a huge brick tunnel, inclosing four smaller ones, the two upper ones, for the sewage, being 12 feet diameter each; the two lower, of 10 feet diameter, for the outfall of the storm water.

At the point of junction of this main tunnel of four sewers with the regular main double high level sewer, the two lower sewers for the storm water have their communication with the upper ones shut off by iron doors. Thus, under ordinary circumstances of wet, the rain and sewage mixed continue their course along the two upper sewers to Barking. In case of violent storms such as occur once or twice a year in London, the water in the upper sewer rises above a certain level marked by a dam or weir, when the doors communicating with the storm sewers are immediately opened, and the mass of flood water allowed to rush unchecked into the Lea River Creek. The works of this quadruple sewer inclosed in one tunnel are, of course, of the most massive description, powerful outer haunches or buttresses supporting the tube outside, and the whole being inclosed in what may almost be termed an embankment of concrete.—*Times.*

ATLANTIC TELEGRAPH CABLE.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—As the Atlantic Electric Telegraph Company have determined to lay a new cable to America, will you kindly allow me to avail myself of your useful periodical to offer a suggestion for a slight alteration in its construction, but which, slight as may be the difference between one cable and the other, may make all the difference in its security, and render any slight flaw or crack which would have been fatal to the old cable, of no perceptible injury to the new one. In testing portions of new cable under pressure they have been found to work perfectly well on their first immersion, and to have continued to do so for two days; and yet on continuing one day longer in the water, making three days, have then become perfectly useless, and it has been subsequently ascertained by examination that the cause of failure was an aperture in the gutta-percha slight as would be made by the prick of a pin. As the distance between the outside of the gutta-percha and the wire would not be more than a quarter or half an inch the water would probably penetrate through the aperture in a few minutes, certainly within a few hours; so in the case stated the water must have penetrated to the wire very soon after the cable's immersion in the water, yet we find that for two days no perceptible injury was done to the cable, though the water must have been in contact with some small portion of the wire during nearly the whole of that time, but after the lapse of one day more the electric powers of the cable are found completely destroyed; this fatal result can only have been produced by the electric wire having been inclosed within a tube, which would necessarily leave a vacuum or empty space between the gutta-percha and the wire, and in this space the water would gradually accumulate, and cover a greater and greater portion of the wire, thus gradually destroying the isolation effected by the outer covering of gutta-percha, this effect being produced almost imperceptibly from the slight admission of the water. The wire in the first instance being only affected over a space which might be covered by the point of a pin, and the isolator being made to adhere directly to the wire, the injurious effect would have extended no further; and would in fact have produced no perceptible injury, though completely fatal effects were produced by the vacuum left between the wire and gutta-percha. The use of gutta-percha cement, or any other adhesive isolator, would prevent any slight crack or flaw producing any injurious effect upon the cable, rendering the cable much more secure than it possibly can be under the present mode of construction, and for the same reason a thick wire would be likely to answer better than a thin one, as a slight prick or flaw would leave only a smaller proportion of its surface exposed to the action of the water. Silver's patent application of india-rubber as an isolator would probably adhere so closely to the wire as to leave no vacuum. At any rate, this effect would be most certainly obtained if two or three coatings of liquid glue (shell-lac dissolved in wood naptha) were applied to the wire previous to the application of the india-rubber.

Might I be allowed to offer a conjecture respecting the old cable, I should say the case of the shareholders was not so desperate as is generally supposed. The injury which has proved at present fatal to the cable is most likely to have arisen in that portion of the cable left suspended between the level under the deep water and the shallow level near the land; as it is certain that that part of the cable, from having been left suspended, and (instead of resting on the ground) having all its own weight to bear from being suspended without support, must have been exposed to a greater strain than any other portion of the cable; and the injury will probably have occurred either in that part resting immediately on the shallow level or about the middle of the part suspended. This supposition is strengthened by the tests applied by electricians showing the failure of the cable to have occurred within that specific distance. This small portion of the cable being in shallow water and near the land, would at the time have been easily recovered, but after this lapse of time its recovery may be very difficult, and the best chance of making the cable available has been thrown away. Still it may yet be recovered, and if the crack or flaw has really occurred within that distance, the rest of the cable may still be found in working order, and a comparatively trifling expense bring the whole cable once more into successful operation.—I am, &c.

Digitized by Google

ON SUBMERGING TELEGRAPHIC CABLES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—The January number of your Journal contained a review of our paper, read in February 1858 before the Institution of Civil Engineers.

2. In the absence of one of us (Mr. Longridge, who has lately returned from Mauritius) a reply was forwarded to you by the other (Mr. Brooks), which however you declined to insert, on the ground that the paper reviewed being a joint production, each author might demand the right of reply.

3. We now claim the redemption of your promise to insert our joint remarks upon the criticisms of your review.

4. Your reviewer commences by asserting that "no results ought to be adopted without strict scrutiny of the steps of the investigation by which they are arrived at." In this we fully concur, but with the proviso that the scrutineer be candid, careful, and competent. How far the reviewer of our paper possesses these qualifications the following remarks will enable your readers to judge.

5. The first paragraph in page 30 states, "We observe also a wide divergence between the results expressed in the paper just mentioned (*i.e.* ours) and those of the Astronomer Royal;" and again, "In the discussion at the Institution of Civil Engineers, recorded in the volume before us, Prof. Airy expressed (p. 80) his dissent from the principal conclusions of Messrs. Longridge and Brooks;" and again in the last paragraph of the review (p. 31), "Considering the warning which Prof. Airy had given to the Institution of Civil Engineers respecting this paper, we think we are fully warranted in saying that the Institution should have subjected the paper to competent revision before issuing it to the world stamped with their approval and authority."

6. These sentences prove that your reviewer is ignorant as well of the facts of the case as of the rules by which the Institution of Civil Engineers is guided in awarding premiums. In the publications of the Institution it is expressly stated that the awarding a premium is not to be understood as conveying any sanction to the views of an author. Whilst we disclaim any such sanction for the conclusions contained in our paper, we may at the same time remark that our conclusions were very generally admitted and agreed to by those members of the Institution who took part in the discussion.

7. It was with some surprise that we read the assertion of your reviewer that Prof. Airy had dissented from our conclusions during the discussion at the Institution. We did not remember the expression of any such dissent during the discussion. We therefore referred to page 80 of the pamphlet under review, and the only passage we could find conveying any opinion on our paper is the following: "Still he (the Astronomer Royal) might show the necessity for caution in accepting some of the deductions in these *two* papers."

8. This, Sir, is certainly a very mild form of "expressing his dissent from the principal conclusions" of our paper, or of "warning the Institution respecting this paper," as your reviewer would have it believed. But mild as it is, its strength is still further diluted when the circumstances are stated under which Prof. Airy made use of the expression recorded as above.

9. Prof. Airy was not present at the Institution of Civil Engineers when our paper was read. He had not seen the paper when he commenced the discussion upon it on 2nd March, 1858. He had neither examined the paper itself nor the Appendix containing the mathematical reasonings from which the conclusions were deduced. He seemed to be entirely ignorant that any attempt had been made by the authors to submit the problem to mathematical analysis. The only knowledge he *could* have of what we had done was through the very meagre abstract usually printed by the Institution, and sometimes published in certain scientific journals.

10. Prof. Airy therefore came to the Institution ignorant to a great extent of the views we held, and as he wished to leave early to catch the train to Greenwich, we were requested to waive in his favour the right of making the usual prefatory remarks before the opening of the discussion.

11. Prof. Airy's observations on that occasion were based on the hypothesis that the resistance of the water had a very slight effect on the deposition of the cable; and the table of tensions which he then produced was simply a table of catenarian strains calculated by the ordinary formula for a suspended chain or rope. On the succeeding night of the discussion, Mr. Gravatt, on the part of Prof. Airy, entirely withdrew this table as even approximative to the actual circumstances of the case, and it was not till the 27th April, six weeks after the discussion was closed, that Prof. Airy again came forward with the "Further Observations" referred to at p. 141 of the pamphlet under review. In these "further observations" the learned professor does not refer to our paper except for the sake of refuting an opinion, *not ours*, but which we had *quoted* as having been expressed at the Meeting of the British Association, and respecting which we said it was so curious and improbable that it had attracted our attention, and which in an after part of our paper we entirely disproved.

12. In the paper subsequently published by Prof. Airy in the *Philosophical Magazine* our paper is not even mentioned, and we therefore conclude that even then the learned professor was not aware that the question had been treated mathematically by us, still less that the results we had announced were perfectly accordant with those of his own subsequent investigation, except in so far as arose from a difference in his assumptions respecting the actual values and laws of action of the resistance and friction of the water.

13. So much then, Sir, for your reviewer's care in obtaining, and candour in using, the facts of Prof. Airy's opinion on our paper. One word more on this head; your reviewer states "the question is not one to be settled by reference to authority,"—Why then does he commence his review by bringing against us the apparent weight of an opinion never expressed, and end it by reading a lecture to the Institution for not taking a warning never given? Why does he seek unfairly and untruly to clothe that asserted opinion and warning with the deservedly respected authority of Prof. Airy's name?

14. Your reviewer says "A person thoroughly acquainted with the principles and proofs of a mathematical investigation does not form an *opinion* of its accuracy; when he has mastered the steps of the reasoning he knows it to be true or false."

15. We are quite willing to judge him by his own dictum. As regards Prof. Airy we believe that when he published his investigation he had never examined ours, and we have yet to learn that he has ever expressed any opinion thereon. As regards your reviewer we now proceed to inquire how far he has so mastered the "steps of our reasoning" as to justify him in pronouncing on its truth or falsehood.

16. In the second paragraph (page 30) your reviewer states that we *assume* that the resistance of the water acts at every point of the cable in a direction bisecting the angle formed at that point by the cable and the horizon, and he adds that this is "no more than a very inartificial way of stating that the velocity of paying out the cable is equal to the horizontal velocity of the vessel."

17. Now we do not make any such assumption; we show that the direction in question is a strictly geometrical deduction from the circumstances of the problem; and though the steps of the process are not printed in the pamphlet, they are given at full in the original manuscript now in the Institution of Civil Engineers. It is by no means evident *primâ facie* that the direction of the resistance above stated is a necessary consequence of the equality of the velocities of the cable and the vessel. In the next sentence your reviewer says, "this (the bisection of the angle) is stated to be the necessary condition in order that the cable may be laid in a straight line without tension." No such thing is stated in our paper. What we say is this (page 34), "It may be shown, in order that the length A.C (*i.e.* the cable) should be laid without *slack* along the bottom, that the point C must move in a direction bisecting the angle formed at C with the horizon; and this is true of every part of the curve." Thus, Sir, we are made to say exactly the contrary to what we did say; and whilst what we did say is strictly correct, what we are made to say is entirely wrong. The bisection of the angle by the path of a particle of the cable is shown by us to take place whatever may be the *tension* at the bottom, provided the cable be laid without *slack;* and is not, as your reviewer says, a necessary condition of laying the cable without tension.

18. We do assume that the curve is invariable in form, and moves parallel to itself. If your reviewer objects to this, it is sufficient to point out that in the problem we are dealing with, the action of the forces is constant and identical from one moment to another, consequently there is no reason why the cable curve should either alter its form or its position relative to the ship.

19. Your reviewer next objects to the statical treatment of the problem. We may say in reply that bodies moving uniformly in

Digitized by Google

water have been treated statically by Newton, Emerson, Vince, Maclaurin, and almost every writer on hydrodynamics; and we may add that no error of the slightest practical importance can result from such a mode of treatment. As to the words quoted, "enables it to be treated statically as regards the form of the curve," they are quite correct; the so-called "centrifugal force" has no effect in altering the *form* of the curve, but simply increases the tension by an infinitesimal amount.

20. It would occupy greatly too much of your space to discuss fully what your reviewer calls "the effect of centrifugal force." In your March number appeared a paper by Mr. Homersham Cox. In that paper an attempt is made to solve the question by aid of the proposition in dynamics referred to in the paragraph which we are now dealing with. At present we confine ourselves to the simple statement that the total effect of the so-called "centrifugal force" upon the Atlantic cable in the depth of 2000 fathoms, and at the usual velocities of cable and ship, say 6 feet per second, would be to increase the tension by about 8 ounces, if the cable were being laid with a certain degree of tension at the bottom, but in the usual case of no tension at the bottom would vanish altogether.

21. In the next paragraph our process is termed "needlessly complex." It consists simply in resolving each of the forms into vertical and horizontal components and collecting the results. The problem might undoubtedly have been treated by the method of normal and tangential resolution, as done by Mr. Cox, or by supposing the cable to slide down a curved surface, as adopted by Prof. Thomson. We see no great advantage in Mr. Cox's method, nor do we think that of Prof. Thomson so conclusive to all minds. The problem of the curve has been treated in three ways: first, by Prof. Thomson; second, by ourselves; third, by Prof. Airy. The first method is statical, and is the shortest method of deducing the equation; the second is statical, and supposes the water to move against the cable instead of the cable against the water,—this is the simplest method; the third is dynamical, and the most rigid, but the most difficult. All these methods give the same equation for tension. The two first methods agree in their results, and so do the two last as far as they can be compared; indeed, by taking Prof. Airy's hypotheses, and proceeding according to the censured "statical" method, the whole of Prof. Airy's results can be obtained.

22. With respect to the remark that A (equation 8) is variable, but in integrating is treated as constant, and that therefore "it need scarcely be added that the result is erroneous," we would remark that equation (8) is derived from equation (5), and that equation (5) has the word "nearly" after it, and in the body of the paper, page 10, it is stated that "the general differential equation for tension cannot be exactly integrated; but the supposition upon which the integration has been effected, is one that will not materially influence the result, and in fact becomes strictly true if the tension at the bottom = 0. In fact, as Prof. Airy states, "the accurate solution offers almost insuperable difficulties to mathematical treatment."

23. The accurate solution, if it were possible, would differ by an almost imperceptible amount from what we have given, and the difference would vanish in the only practically useful case, viz., when the cable assumes a rectilineal form; under these circumstances we think that a candid reviewer might have left our disclaimer of perfect accuracy in the general case as it stood, instead of stigmatising our results as erroneous.

24. In the following paragraph your reviewer notices the case of the cable assuming a rectilineal form in its descent, and says, "the cable may possibly assume this form, but will not generally do so;" and "such a case might happen, because whatever be the weight of the cable, the resistance might be varied to any extent by varying the velocity of the vessel."

25. Now we would observe, that in practice the cable not only *may* but actually *does* assume the rectilineal form, and it does so *whatever be the velocity of the vessel*, the only necessary condition being the absence of tension at the bottom, which can always be attained by paying out at the smallest conceivable rate greater than that of the rate of the vessel.

26. Again he says, "the case in which the form of the cable would be a straight line is obviously this, when the resistance perpendicular to that line is equal to the effect of gravity resolved perpendicularly to that line."

27. Now this is not the necessary *condition* of the cable being straight, but simply a necessary *result*. The condition is that there is no tension at the bottom.

28. If, as we are disposed to believe, Mr. Cox be the reviewer of our paper, it would appear that he has seen reason to alter his opinion as to the rectilineal form being only a *possible* case, for at page 74 of your March number it is stated, "that when the velocity of paying out, and the velocity of the ship and the depth of water are constant, the descending cable assumes the form of a straight line inclined at such an angle that the normal resistance at every point is equal and opposite to the effect of the weight resolved perpendicularly to the line."

29. Your reviewer proceeds to remark "that the conclusion arrived at by the authors in problem 3 is directly opposite to the conclusion at page 9 of the paper."

30. The "conclusion," as he calls it, at page 9 is in fact no conclusion at all in the sense in which the word is used in the first member of the sentence. The one is the mere expression of what might at the first glance be *expected* to take place; whilst the other is a rigid deduction from the mathematical treatment of the question. We fully admit that, instead of the words, "indeed a little consideration leads us to an opposite conclusion," we ought to have written, "indeed a little consideration *seems to lead* us to an opposite conclusion;" but this could mislead no one, for the whole of the paragraph in question is evidently only the expression of what might be expected previous to accurate investigation; and a few lines further on we actually use the words, "it is to be expected,"—plainly showing that the reasoning was not conclusive as to results.

31. "The argument which follows," and what your reviewer is pleased to call "a strange jumble of statical and dynamical ideas," we presume refers to problem 3, but as he has not thought fit to analyse it we are unable to meet his objection otherwise than by the counter-assertion, that there is no discordance whatever between the paper and its appendix.

32. As regards problem 4, our equation is

$$t = w.x - q^1 V^2 \left(\frac{v}{V} - \cos A\right)^2 \operatorname{cosec} A.x$$

v being the velocity of the cable, and V the velocity of the ship. And yet your reviewer coolly informs your readers, that we assume that "the friction along the cable varies as the square of the velocity of the ship *only*. An error which entirely vitiates the conclusions arrived at."

33. It is difficult and painful to reply to wilful mis-statements, but those already pointed out are not the only ones which appear to merit such a designation. In the following paragraphs we are accused of supposing the case of "a small plane disk" descending in water, and of "assimilating the motion of a small inflexible disk to that of a long flexible cable."

34. If your readers will look to problem 2, that now under review, they will find not one word about "a small plane disk" but the title "Equations of motion of a body descending uniformly in an oblique position through a resisting medium." They will see also a diagram evidently refering to a portion of a long body. They will also find q and q^1 stated to be the co-efficients for resistance and friction per unit of length, and they will find (p. 6) that the problem expressly refers to a rod, and not to a "small plane disk."

35. But apart from this, your reviewer's remarks are utterly fallacious. He says "they suppose the body to be a small plane disk not subject to any force but gravity and the action of the water. They suppose further, that if the body be placed obliquely in water it will descend, moving parallel to itself, and every part of it moving with uniform velocity in a straight line." And then he adds "the two suppositions are inconsistent with each other; for if the body be subject to no forces but those mentioned it will rotate, the velocities will not be uniform, and the path of its centre of gravity will be curvilineal." We are unable to perceive any inconsistency in these suppositions in the case in question, viz., that of a body descending uniformly in a resisting medium. We are quite aware that mathematically this is impossible, because as we showed in problem 1, a body descending under the action of gravity would only acquire a strictly uniform velocity at the end of an infinite time; but we showed also that in the case of the cable it so soon acquired very nearly its ultimate velocity that practically the ultimate velocity might be used without error. It is therefore a mere cavil to assert that the conditions of the problem are impossible when the only forces are those of gravity and resistance of the water.

36. As to the rotatory motion we confess our inability to discover its source. There are three forces—gravity, resistance, and

Digitized by Google

friction. If these forces create rotation we should find that crows, instead of skimming the air with tail and wings outspread would be always toppling over like tumbler pigeons, for they have those same three forces; gravity, resistance of air to under part of their wings and tail, and resistance in front, equivalent to friction in the direction of forward motion.

37. Your reviewer says that the tables at p. 7 "are not entitled to the least reliance." "That a cable running out free from tension is a pure abstraction," and that to suppose a telegraph cable to descend free from tension is simply absurd.

Such assertions are easily made, but in the review of the results of mathematical investigation something beyond assertion is requisite, and the more so when that which is in itself easily practicable is by the reviewer pronounced to be "a pure abstraction," and "simply absurd."

When your reviewer has proved that the tables given at page 7 are constructed from erroneous formulæ he will be entitled to pass the severe judgment upon them which he now so unhesitatingly pronounces. Until then we trust that your readers will refrain from pinning their faith to his assertions, and reserve their judgment until he produces his proofs.

38. With respect to the 6th problem, it is objected that we have neglected the force of gravity, and that the curve will be one of double curvature. Here again your reviewer has assumed his own case for the purpose of objecting with some show of reason to ours. We are dealing with the effect of a current on a cable during the operation of laying. We have already shown that in the usual and what ought to be the universal case in practice, viz., that of laying with no tension at the bottom, the cable takes the form of a straight line, and that that straight line, though travelling in space, is unvaried in direction so long as the velocity of the ship and of paying out, &c. remains constant. The question then arises, what is the result of a current acting upon this line? It is evident that it matters not whether its direction be horizontal, vertical, or oblique, and the action of the current will be precisely the same in each case. What then is the effect of the action of a current moving at right angles to the horizontal projection of the cable descending in a straight line to the bottom? We have shown that the effect of a current upon a line stretched across it is to make that line assume a catenarian form, but differing from the common catenary in this, that the tension throughout is constant; consequently, if there be any tension caused by the current, that tension must exist at the bottom, but this is inconsistent with the supposition of the cable being paid out at the same velocity as the ship, and under the tension due only to the depth of water. Under these circumstances the additional tension at the bottom due to the current must be $=0$, and the additional tension being constant it must $=0$ throughout; and the result is as already stated, that the additional tension caused by a current $=0$. The double curvature can only exist where there is tension at the bottom, a case which ought never to occur in practice.

39. Again it is said that some of our remarks on this problem are curious, "of which the only one of which the meaning is plain is erroneous," viz., that it is not correct to say "that a catenary cannot exist without tension at the bottom, for by a proper disposition of forces a cable may be made to assume any form whatever, and to be without tension at any point." Your reviewer seems to have forgotten that in the case we are dealing with, the forces are fixed and definite, and that it was not our intention to solve a problem concerning the result of *a possible disposition of forces*. By a possible disposition of forces a cable might be sustained horizontally and free from tension in mid air between two points however distant, but such dispositions of forces have no reference to the operation of laying telegraphic cables.

40. Your reviewer next adverts to problem 8, which he appears entirely to have misunderstood. The problem supposes that whilst the cable is being deposited without tension at the bottom, and consequently in a rectilinear form, the vessel and paying out are stopped. Of course the cable will then lose its rectilinear form, and begin to assume or to take the form of a catenary, becoming ultimately a common catenary, the tension then reaching its maximum. The problem gives this maximum tension and the ultimate form of the curve, and is perfectly correct. Your reviewer seems to object to the expression "suddenly stopped," but though these words are in the title to problem 7 in the Appendix, it will be seen by looking to the body of the paper that the word "suddenly" is not used, and that the case in practice is that of the simultaneous, but not instantaneous stoppage of the ship and cable. It is in fact expressly mentioned that the ship could not be stopped instantaneously, consequently the "jerk" referred to by your reviewer could never occur. Practically, as the cable descends in a rectilinear form, absolutely instantaneous stopping must produce fracture unless the cable be very elastic.

41. Lastly your reviewer refers to problem 11, and says that Tr should have been used instead of $(T-R)r$. Now R is the normal tension at the mean level, (that is to say) the tension which would exist if the sea were perfectly smooth, and therefore equivalent to the resistance of the breaks, R is therefore constant and always acting; and therefore $(T-R)r$ is the correct expression, and not Tr as asserted by your reviewer.

42. We have now, Sir, gone through the whole of the objections raised against our paper by your reviewer, and have shown that without exception they are groundless, and we leave it to your readers to decide how far the scrutiny has been conducted on his part with that candour, care, and competency which we are entitled to expect in the review of any scientific work. We do not pretend that our paper is complete or perfect. As we said in its very first paragraph, it claims to be "no more than a partial solution of an interesting and somewhat complicated problem." It was we believe almost the first attempt to rescue the art of cable-laying from the charge of empiricism, and to apply thereto the principles of mechanical and mathematical analysis. Since then the matter has been partially treated by Prof. Airy, and we are glad to find his conclusions fundamentally the same as ours.

We are, &c.,

JAS. A. LONGRIDGE,
C. H. BROOKS.

18, *Abingdon-street, Westminster,*
14th July, 1859.

[A reply to this communicatiou will appear in our next number.]

SURREY ARCHÆOLOGICAL SOCIETY.

UNDER the auspices of very favourable weather, and a goodly company of members and visitors, the sixth annual meeting of this society took place at Richmond on the 5th of last month; the president of the day being Lord Abinger, who is vice-president of the society. The opening meeting was of course a business one, and was held in the National schools, when the report of the past year with the accounts, &c. was read by the hon. sec. Mr. G. B. Webb. After other necessary preliminaries of the same nature, the following papers were read:—"Notices of the family of Cobham, of Starborough castle, Lingfield, Surrey," by J. W. Flower, Esq.;—"Notes from the parish registers of Richmond," by W. H. Hart, Esq., F.S.A.;—"On the antiquities of Richmond," by W. H. Chapman, Esq., local hon. sec. The meeting subsequently adjourned to the parish church, and examined the numerous ancient and interesting monuments it contains, and upon which remarks were offered by the Rev. W. Bashall. It had been intended, we understand, to visit that most interesting old mansion, Ham House, in the immediate vicinity of Richmond, but circumstances out of the control of the managers of the arrangements prevented the accomplishment of this, for the present at least.

In the afternoon a temporary local museum was opened in the lecture hall of the Cavalry College, the whole area of which, as well as the walls, were covered with objects bearing upon the general objects of the society. Among these may be specified ancient spurs, daggers, keys, stirrups, manacles, &c., of various dates, found at Hackney, and exhibited by Mr. J. R. D. Tyssen; a spur from Mourne Abbey, in Ireland, of about the date of Edward III., exhibited by Mr. A. H. Clutterbuck; the gossip's bridle, belonging to the porch of Walton-on-Thames, Surrey; ancient pistol, tinder-box, cross-bow, penitential chair, various halberds; a curious collection of spurs of various dates, ranging from the time of Edward II. to that of Charles I., exhibited by Mr. Thomas Mills; an ancient horseshoe, found at Dowgate, exhibited by Mr. Mills; a breastplate used in the times of the civil wars in the reign of Charles I.; a number of curious blunderbusses of the reign of Queen Anne; a swivel gun taken at the Battle of Copenhagen by Admiral Duncan; a South African gun, an Irish brass blunderbuss, two halberds of the time of Francis I.; various rubbings from brasses; brasses from the parish church of Weybridge in Surrey, exhibited by Mr. Hart; a great number

Digitized by Google

of ancient keys, exhibited by Mr. T. Mills; a series of coins in gold and silver from the time of Henry II. to that of George I.; a curious hour-glass stand from Hackney Church (exhibited by Mr. Tyssen); an iron catchpole from Sweden, a South African spoon, and weapons of various kinds from New Zealand; casts of various ecclesiastical seals; gongs; a spear-head found in the barrow of Teddington; drawings of Surrey churches (contributed by a lady); a collection of casts of inscriptions on bells in various parts of England (exhibited by Mr. Tyssen); an ancient Celtic corn-mill; some pieces of ancient pottery; a likeness of Charles II., framed in wood belonging to an oak which once grew at Petersham; the chair of Henry, Prince of Wales, bearing the arms, beautifully embroidered, of his mother, Anne of Denmark; an English chair of the year 1530; deeds with seals, ranging from the thirteenth and fourteenth centuries (exhibited by Mr. J. J. Howard); some autographs of eminent men; some curious hand-bells; a drawing of the famous tapestry of St. Mary's Hall, Coventry; several pieces of tapestry from Ham House; specimen of binding in 1470 (exhibited by Mr. H. G. Bohn, who exhibited various other articles of interest); curious antique jewellery, found in various parts of the world; illuminated books in antique letters and curious bindings; Roman urns, jars, &c.; impressions from various seals; portraits of the Duke and Duchess of Montague, about 150 years old (exhibited by Mr. H. G. Bohn); several remains found at the foot of Stratford Hill (exhibited by Mr. Tyssen); portrait of Lady Hatton, wife of Sir C. Hatton, by Vandyke (exhibited by Mr. H. G. Bohn); specimens of wood carving (exhibited by Mr. H. G. Bohn); Chertsey Abbey encaustic tiles; Roman and Mediæval pottery, specimens of wall-painting; tesselated pavements; a number of curious coins, casts, drawings, paintings, &c.; Edmund Burke's chair, &c. &c.

INSTRUCTIONS ON THE USE OF WATERGLASS IN PAINTING, AND FOR HARDENING STONE.*

By Fr. Kuhlmann, Professor of Chemistry at Lille.

The application of the soluble silicates in hardening stones and in painting has now been sanctioned by experience to such an extent,† that it may be considered as one of the most useful conquests which the art of building has made for many years past. This is the unanimous judgment of the most competent men of science, as expressed in learned societies, at scientific meetings, and by the international jury of the Great Exhibition of 1855 at Paris.

I thought that little good would be done to the art of building, by merely pointing out to the public the results of new observation, or by directing attention towards the causes of the observed phenomena, and referring to their scientific, industrial, and artistic applications, but that builders and painters ought also to be specially initiated into all the details of the many useful applications of the new chemical product, which is as yet but little met with in commerce, and the employment of which is in itself an innovation in architecture and monumental painting. I have endeavoured to produce these silicates economically, and on a large scale, and to render their application practicable. By enabling builders and painters to profit by my own experience, I hope to spare them the trouble of numerous trials, which from clumsiness or ignorance often lead to failures, and thereby delay the general application of an invention.

Although I was determined from the beginning of my researches not to make my investigation of the soluble silicates the object of a mere French interest, I have nevertheless thought it desirable to ensure for myself the right of priority, in order to be able to repel any attempt which might be made to usurp my rights, and to give up the fruits of my researches to the public after possessing the guarantee of having them protected by letters patent, which never fail of effectually aiding a new discovery which is of interest to manufactures and the arts.

I have established works for the manufacture of the soluble silicates, or waterglass, in the Department du Nord; and the process adopted is so simple and economical, that in spite of the present high price of the alkalies, these silicates can be delivered by the house of Kuhlmann and Co., at Lille, at the following prices:—

100 kilogrammes (200 lb.) of silicate of potash, in solution, marking 35° Beaumé, at	35 francs
100 kilogrammes of solid silicate of potash at	90 ,,
100 kilogrammes of silicate of soda, in solution, marking 35° B....	30 ,,
100 kilogrammes of silicate of soda, in solution, marking 50° B....	40 ,,
100 kilogrammes of solid silicate of soda	70 ,,

These products are also to be had at the Central Dépôt in Paris, from M. J. Drouin, Rue Ste. Croix de la Bretonnerie, No. 21, at 5 francs more per 100 kilogrammes.

1. *Hardening of Stones.*

Silicate of potash is advantageously employed for hardening porous stones, as well as for consolidating soft sandstones or bricks. Silicate of soda, although producing the same effect with regard to hardening stones, gives rise after some time to unsightly efflorescences.

Preparation of the siliceous solution.—A solution of silicate of 35° strength, such as may be had in commerce, contains a third of its own weight of solid or vitreous silicate. It has been made of such a strength, as to render it necessary to dilute it with twice its own volume of water, in order to obtain a liquid of the proper concentration for hardening stones. Builders who are little acquainted with chemical manipulations are thus enabled by means of these simple indications to employ either the solid or the liquid silicate. The silicate of 35° ought to be diluted with twice its volume of water; and the solid silicate requires to be dissolved in six times its own weight of water. The solution of the solid silicate is not quite without difficulties; it is more easily effected in water which has already been charged with a little silicate, than in pure water. This is heated to ebullition in an iron boiler, and the silicate added in the state of powder, or in small pieces.

These proportions need not however be rigorously adhered to. A siliceous solution of a slightly different degree of concentration may still give good results. I would however remark, that too weak solutions require frequent repetition of the process of impregnation, whilst too concentrated solutions are ill-suited for a thorough penetration, and consequently for a proper hardening of the stone.

Mode of action of the solution.—The siliceous solution, when brought into contact with porous stones in the manner to be explained hereafter, is absorbed by them. After exposing them for some time to the air, they will be able to absorb a fresh portion of solution, and in a similar manner a third and a fourth; but the quantity of liquid thus absorbed diminishes with each new operation, and at last absorption ceases altogether, when the pores of the stone are completely filled with the siliceous matter.

The quantity of solution which may be thus absorbed varies with the nature of the stone, the coarseness of its grain, and its porosity. It is calculated, however, that a calcareous stone of average porosity can be effectually treated with silicate at 3½*d.* per square yard.

The hardness of the stone will depend as well on the quantity of silicate absorbed, as on the quality of the silicate which has been employed; so that if the work is done by contract, the proprietor may be liable to serious miscalculations.

Method of applying the siliceous solution.—This varies with the nature of the buildings which have to be treated. In more recent constructions it may be applied at once; but in older buildings the stones require to be cleansed, in order to facilitate the absorption of the siliceous solution. Mere washing rarely suffices; and scraping will always be found preferable whenever it is applicable, or else washing and scrubbing with a hard brush, or with a solution of caustic potash; acidulated water must on no account be used.

If the stone be of small extent, such as a statuette, or a piece of ornament, the siliceous solution is applied by simple immersion for some hours, which ought to be repeated several times.

Large surfaces are coated with the silicate by means of fire-engines, or large syringes with broad rose-nozzles, taking care to collect at the foot of the walls, by means of gutters made of burned clay, of plaster, or of cement, the excess of the liquid, which may again serve for fresh operations till it is entirely exhausted. When the silicification is only applied to certain portions

* Translated from the French by desire of and communicated to the Society of Arts by the Prince Consort.

† A considerable number of public buildings have been successfully treated with waterglass, amongst which are the Louvre and Notre Dame at Paris, the Cathedral of Chartres, the Napoleon Barracks, the Exchange at Lille, and various churches and buildings in the Department du Nord.

Digitized by Google

Digitized by Google

DOWLAIS WATER BALANCE MACHINE.

Fig 1. *Elevation*

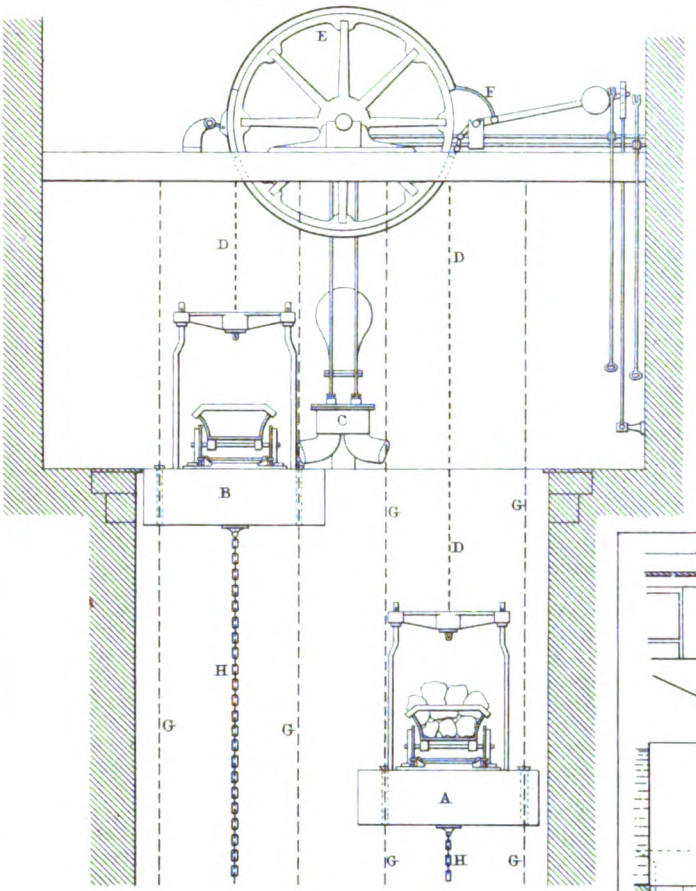
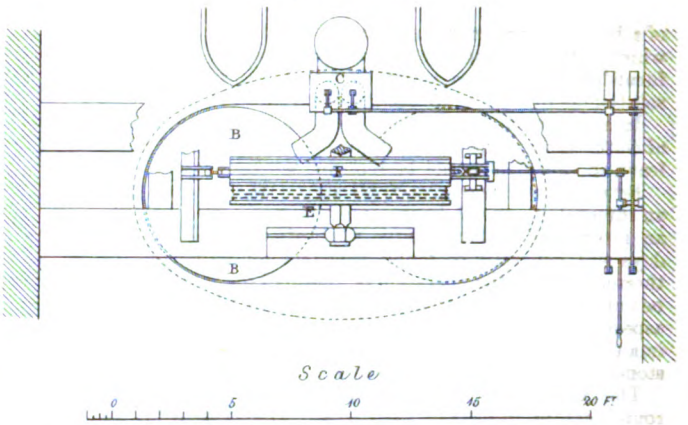


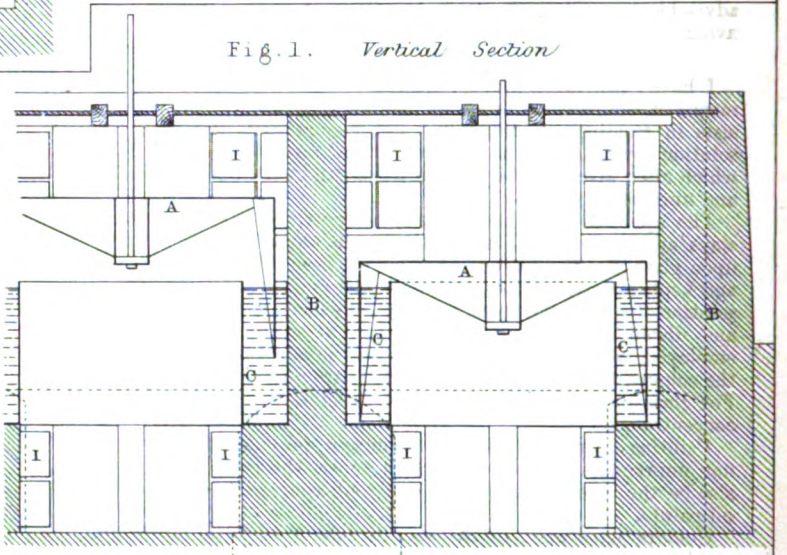
Fig. 2. *Plan*



Scale

0 5 10 15 20 FT

Fig. 1. *Vertical Section*



STRUVE'S MINE VENTILATOR.

Fig. 3. *Sectional Elevation*

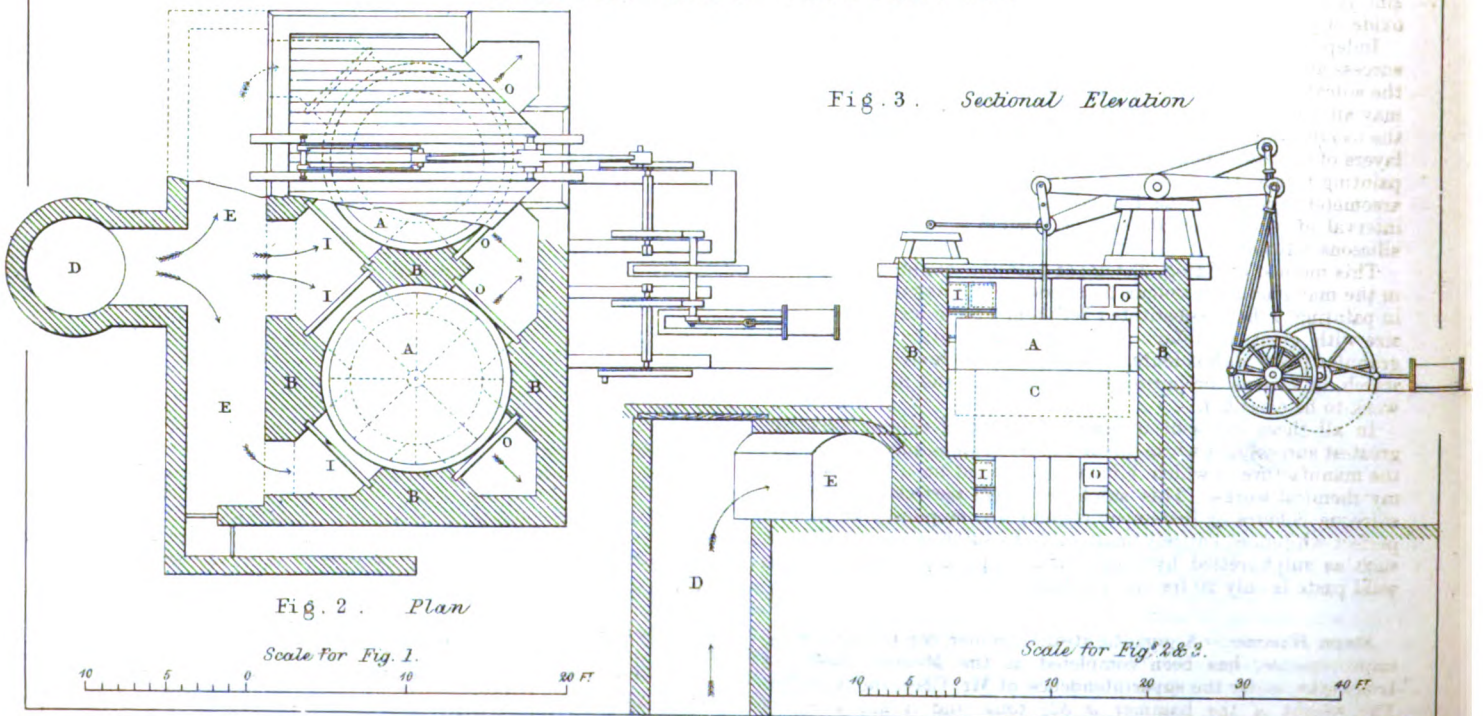


Fig. 2. *Plan*

Scale for Fig. 1.

10 5 0 10 20 FT

Scale for Fig.s 2 & 3.

10 5 0 10 20 30 40 FT

August 1859

J.R.Jobbins

Digitized by Google

of a building, *e.g.* upon sculptures, a soft brush may be employed, which acts like a sponge, retaining a quantity of liquid, so as to furnish to the surfaces which have to be silicified as much of the solution as by way of sprinkling or immersion.

In all cases the window-glasses have to be protected by means of cloths against the action of the siliceous solution, which would leave spots which cannot be removed when once dry.

Between two successive applications of the siliceous solution an interval of several hours ought to be allowed, or, better still, an interval of a day. Three applications on three consecutive days will generally be found sufficient for hardening the stone thoroughly. If the operation be repeated too often, the stone will be found coated over with a vitreous coat of a shining disagreeable aspect, which would necessitate repeated washings with water immediately after the last besprinkling. There are, however, stones so porous that this inconvenience will hardly show itself.

The application of the silicate may be effected all the year round, except in days of hard frost. Dull weather is preferable to warm and dry weather. When the sun is shining warm, it is advisable to protect the work by means of cloths, in order to avoid too rapid desiccation.

2. *Siliceous Painting and Printing.*

I have substituted the application of the siliceous colours by means of the painting brush for the German process, which consists in treating paintings in water-colours with the siliceous solution by means of a syringe with a rose-nozzle—a process which often gives rise to unequal fixing, and which is of difficult and uncertain execution.

The application of the colours, however, is done in various ways and conditions. In painting upon stone, upon a wall, or upon glass, &c., the colours, after having been ground with water and kept in a pasty state, are immediately mixed with a siliceous solution of 15 to 20 degrees, and applied exactly as in oil painting and distemper painting, except when a very porous stone is employed, which had better be slightly silicified before applying the colours, to prevent a too rapid desiccation by the porous body. For glass and earthenware the siliceous solution ought to be more concentrated.

Painting upon wood is equally efficient, provided the wood be not impregnated with resin, which repels the colour, as would also be the case if one were to apply siliceous painting over old oil-paint.

Colours acted upon by the alkalies cannot be advantageously employed for this kind of painting. Those which answer best are the ochres, blue and green ultramarine, oxide of chromium, zinc yellow, sulphide of cadmium, red lead, calcined lamp-black, oxide of manganese, zinc white, artificial sulphate of baryta, &c.

Independently of this method of painting, I have with great success applied a kind of mixed style of painting to rooms, where the silicates merely serve as a means of fixing the colours, which may afterwards be washed with water. The painting is done in the usual manner in distemper, and, in order to fix the colours, two layers of silicate of potash or of soda are applied by means of the painting brush; the first layer with a solution of 6° of Beaumé's areometer, and the second of about 10° strength, allowing an interval of some hours at least between each application of the siliceous solution.

This method of fixing distemper painting might be employed in the manufacture of coloured papers. For this purpose (as also in painting) I have substituted fecula or starch for the ordinary size with great advantage. But as starch gives a somewhat granular paste with colours, I add to it some dextrine or soluble starch, in various proportions, according to the fineness of the work to be executed.

In all these kinds of distemper-painting I employ with the greatest success as a white colour the artificial sulphate of baryta, the manufacture of which I have established on a large scale in my chemical works. This sulphate covers perfectly well when siliceous colours or distemper colours are employed; it is of a perfect whiteness, entirely unalterable by sulphurous emanations, such as sulphuretted hydrogen; and its price in the state of a solid paste is only 20 frs. the 100 kilos.

Steam Hammer.—A gigantic steam hammer, combining various improvements, has been completed at the Mersey Steel and Ironworks under the superintendence of Mr. Clay, the manager. The weight of the hammer is 32¾ tons, and it has a fall of about 20 feet.

THE PROGRESSIVE APPLICATION OF MACHINERY TO MINING PURPOSES.*

By THOMAS JOHN TAYLOR, Newcastle-on-Tyne.

(*With Engravings.*)

THE object of the paper was to trace the progressive application of Machinery to Mining purposes; more especially to the drainage of mines and raising of coal in the Newcastle coal district. By the old miner the shallow mines were easily worked, and drained by adits, many of the coal beds being found above the natural drainage levels of the country: in a middle period, when deeper mines were to be worked, a perpetual struggle arose for the necessary mechanical powers, a struggle resulting in many contrivances, some of which were very ingenious: and thirdly, we arrive at the epoch of the steam engine, which has ever since continued to be the right arm of mining operations, and has also led to many other mechanical appliances as a natural consequence of the development it has given to mining.

The commencement of the third period of coal mining in the early part of the eighteenth century is marked by the notable epoch of the introduction of the steam engine. The importance of the Northumberland and Durham coal trade at this period may be judged of from the fact that the annual shipments of coal from Newcastle averaged 475,000 tons, and from Sunderland 175,000 tons, the aggregate being 650,000 tons; employing 600 ships of about 80 Newcastle chaldrons each, and 4500 seamen and boys. Under these circumstances it is not surprising that the beds near the surface and above the natural drainage levels were being fast exhausted.

The earliest applications of the steam engine were directed solely to the drainage of mines; and during the first 40 or 50 years after its invention, it does not appear to have been thought of for any other purpose, Savery called his little publication in 1699 on this subject the 'Miner's Friend;' but Newcomen and Crawley in 1710 were the first who rendered the engine suitable for practical applications. In 1713 an engine was constructed at Byker near Newcastle; and at very nearly the same time two others were erected in that neighbourhood, one at Washington Fell and the other at Norwood. The engines were at that time worked by attendants, who opened and shut the valves, until Beighton of Newcastle, in 1718, introduced a great improvement, by which they were rendered self-acting. Stewart observes that in 1714 only four steam engines were in existence, two of which were upon mines in Newcastle. A few years after this date an engine was constructed by John Potter, of Chester-le-street, in Durham, for draining Edmonston Colliery, the particulars of which have been preserved; the cylinder was 29 inches in diameter, and made of brass, as also were the buckets and clacks and one of the working barrels: the pumps, 9 inches in diameter, were made of elm hooped with iron; the boiler top was of lead. The introduction of the steam engine, imperfect as it still was, not only enabled deeper mines to be won, but also cheapened the cost of drawing water, as compared with that by horses, in the ratio of about 7 to 1. The pumps, at first of wood, were afterwards made of cast-iron.

Long after the introduction of the double-acting engine, the work was distributed over the up and down stroke by means of a dead weight acting on a separate balance beam; and this old custom is still adhered to in some parts of the Newcastle district. A step in advance was the application of the V bob, consisting of a V shaped radius link vibrating on a centre, fixed at a short depth down the pit, by means of which the beam was made to lift from both ends, with corresponding sets of pumps in the pit: some of the older engines are still worked in this manner. In a third improvement this oblique mode of applying the power was replaced by a direct lift from each end of the beam, a separate pit or staple being sunk for the purpose, as is the case at the Hester Pit, Hartley Colliery, near Newcastle. In this case the depth of the pit is 600 feet, the engine of 300 H.P., and the pumps 31 inches in diameter, made of wrought-iron; the total cost of the engine and engine-house was £12,750. The quantity of water raised is 750 gallons per minute, making 382,395,200 gallons or 1,707,120 tons in a year; the total working expenses, including 8960 tons of coal consumed, are £1575 per annum, exclusive of interest of capital: hence the cost of raising the water from a depth of 600 feet is 0·22*d.* per ton of water raised. In two other cases it is found that the cost is respectively 0·27*d.* and 0·21*d.* per

* From a paper read at the Institution of Mechanical Engineers.

Digitized by Google

ton of water raised 600 feet. The average is therefore 0·23*d.* per ton of water for 600 feet depth, which may be taken as the mean cost of pumping water in Durham and Northumberland, exclusive of interest and redemption of capital. Under the old system as already stated, a horse could raise 10½ tons per day from a depth of 300 feet; and reckoning 4*s.* 6*d.* per day for the horse, driver, wear and tear of ropes, &c., this gives 5·14*d.* per ton raised 300 feet, or 10·28*d.* per ton raised 600 feet: while from the same depth the same weight is raised by the steam engine for 0·23*d.* Hence the cost is 45 times more by horses than by the steam engine: besides which the increased depths at which modern mines are worked render them absolutely inaccessible by horse power.

Attempts are being made to dispense with the cumbrous weight of beams, by placing the pumping engine vertically over the mouth of the pit, the pump rod being worked direct by the steam The direct-acting pumping engine at Burradon Colliery, near Newcastle, is an example of this arrangement. There are here two cylinders of 60 inches diameter and 6 feet stroke, having their piston rods connected at top by a crosshead, to the centre of which the pump rod is attached, passing down between the cylinders. The pump rod is made continuous throughout the entire series of pumps, passing through a stuffing box at the bottom of each working barrel; there is thus only a single pump rod for the whole depth, instead of a separate rod for each set of pumps as required in the ordinary arrangement, thereby greatly reducing the dead load upon the engine. The water is raised from a depth of 900 feet; and the total cost of the engine, pumps, and building was only £4600.

Pumping by a rotary motion is now much practised, especially in sinking pits: the crank engine being handier for application, whilst its greater number of strokes per minute has the effect of keeping the water better and more uniformly out of the bottom.

But though the great mining problem was solved by the application of the steam engine in the early part of the last century for raising water from mines, the miner having been enabled by its means to win the deeper coal of the field, thus acquiring an entirely new mining territory, still many years elapsed before steam power was applied directly for raising coal: and in the meantime various mechanical means were employed for this purpose. The old horse gin continued in use, and commonly required 24 horses in a day, working four at a time; it was employed at Walker Colliery near Newcastle for a pit 600 feet deep. But it was evident that some substitute must be found for animal power at such great depths. Various applications of machinery were therefore devised, amongst which may be mentioned one by Mr. Menzies, consisting of a descending vessel containing water which overbalanced and brought to the surface a basket of coals; the water was then discharged at the bottom, and if there was not a day level it had to be pumped up again by the steam engine. Notwithstanding this disadvantage, the plan was a simple and effective one, and continues in a modified form to be employed to this day in other districts, though not in the Newcastle coalfield, especially where the water can be got rid of by day levels. Figs. 1 and 2 (Plate XXII.) are an elevation and plan of a water balance machine now working at the Cwn Bargoed pit, Dowlais Iron Works, South Wales. The coal tram, containing about 1 ton of coal, is placed upon the top of the empty water bucket (A) at the bottom of the pit, and the empty tram on the bucket B, at the top; this bucket upon being filled with water descends, raising the empty bucket with the full coal tram. The water is supplied through a valve box C, and air vessel by the Cornish pumping engine used for draining the mine. The landing chain D, is a flat three-link chain, working over a turned pulley E; the motion is controlled by a powerful break, F, and the buckets are guided by ¾-inch long-link chains G. A single-link counterbalance chain H, of the same weight per foot as the landing chain D, is attached at the bottom of each bucket, and hangs loose in the pit, for the purpose of balancing the landing chain. The pit is an upcast shaft, of about 600 feet depth; and the quantity of coal raised is from 250 to 300 tons per day of 12 hours. These water balance machines are extensively used in the Welsh ironworks, generally upon mines having free drainage, where they are a cheap means of raising materials. The cost of erection is small; and a breaksman is not required, as one of the landers at the top of the pit works the break. Even where the water for working the balance machine has to be pumped up by the engine, as in the above case, it is a cheap arrangement for moderate depths, when the quantity of material to be raised is moderate, say under 300 tons a day. The time occupied in filling the buckets limits the amount of work; and 300 tons a day may be taken as the maximum quantity that can be raised with safety by such a machine from a depth of 600 feet. The indirectness of application of the power is more than compensated for by the superior economy in the employment of steam in the Cornish pumping engine as compared with the ordinary high-pressure winding engine.

During the latter half of the last century water wheels were very generally used in raising coals; these were either single wheels, or with a double row of buckets set in reverse order, which enabled the motion to be reversed more expeditiously. Where water was not to be had at the surface, the steam pumping engine was made to pump the water which drove the water wheel; and an extra power was thus expended in lifting the water, equal to that required for raising the coals from the bottom of the shaft. The double water wheel erected at Walker Colliery near Newcastle, by Smeaton in 1778, drew 30 corves, each containing 6 cwt. of coal, from a depth of 600 feet, in an hour, being at the rate of 100 tons per day of 12 hours. In this apparatus a Newcomen engine was employed to pump water into a tank, from which it was discharged on to the wheel by one of two spouts alternately, the wheel having two sets of buckets set in opposite directions for giving a reversed motion; and the lander readily started and reversed the winding by pulling cords at the pit mouth, or stopped the wheel by a cord putting on a break. As late as the year 1797 there were still numerous water wheels, with rope rolls on the same axle, at work in the coal districts of Northumberland and Durham.

The application of the steam engine directly to winding is of recent date. The introduction of the steam winding engine has been the cause of material changes in the underground arrangements: for, by enabling much larger quantities to be drawn daily from a single pit, the necessity for sinking other pits is obviated; and this again has occasioned great improvements in the underground modes of conveyance with a view to increased facilities of transit. With fewer pits better roads are required, and also better ventilation: so certainly does one step in advance lead to others. With the large winding engines now used in the north of England, which are often of as much as 100 to 120 horse power, working upon a first motion, the average performance may be stated at 400 tons raised in 12 hours from a depth of 900 feet: this includes the time occupied in drawing the workmen. The average winding speed in the shaft is from 15 to 20 feet per second, or 10 to 13 miles per hour. In some cases, but not universally, a heavy counterbalance chain is wound round a continuation of the axle of the flywheel, for the purpose of balancing the weight of the long length of rope and tubs full of coal, when in the act of being lifted from the bottom of the pit, against the short length of rope and empty tubs at the surface; the chain works either into a staple (or small pit) sunk for the purpose, or upon an inclined plane.

The double-cylinder winding engine is being introduced with success. In the case of the double-cylinder horizontal winding engine now working at Burradon Colliery near Newcastle, the flywheel and counterbalance chain are dispensed with, and the engine works the rope rolls direct by a first motion. The two cylinders are 26 inches diameter and 5 ft. 6 in. stroke, coupled to cranks at right angles on the shaft of the rope rolls, which are 15 ft. 6 in. diameter, working with a flat wire rope ⅝ inch thick, and weighing about 16 lb. per fathom or 2⅔ lb. per foot. The pit being 900 feet deep, about 18 revolutions are required in winding; so that the diameter of the drum is increased from 15½ to 17½ feet. Each load consists of 25 cwt. of coal, and the time of drawing is just 30 seconds, making the average winding speed 30 feet per second or 20 miles per hour. The time occupied in drawing and changing the tubs is as nearly as possible 1 minute; and the actual winding power is therefore 75 tons of coals per hour from a depth of 900 feet. The engine is worked with high pressure steam of 35 lb. per square inch.

The average cost of raising coals by winding engines, for raising a quantity of 400 tons per day, including maintenance of the wire ropes, coals for the engine, repairs of engine and boilers, and men's wages, is

0·70*d.*	per ton	for	300	feet depth
1·07	,,	,,	600	,,
1·43	,,	,,	900	,,
2·02	,,	,,	1200	,,

Digitized by Google

The average cost of maintaining the pair of wire ropes is £1 per year for each fathom of depth, or 3*s.* 8*d.* per foot per year.

The principle on which the flywheel and counterbalance chain are dispensed with in the double-cylinder engine is the same as that of employing two men, or rather two half-men, instead of one in the original windlass: so long are principles, assumed three centuries ago, neglected before they are brought into practical operation. It is obvious that the double-cylinder engine with cranks at right angles to each other renders a counterbalance unnecessary, by enabling the power of the engine to follow the crank throughout the entire revolution; and for the same reason the flywheel as an equaliser of the power is dispensed with.

After the introduction of the steam engine and its application to mining purposes as a means of drainage, the motive power of horses on railways was succeeded by that of fixed steam engines with ropes, and self-acting planes, methods which continue in use; but even so early as 1813 a locomotive engine was employed for leading coals along the Wylam colliery railway. The Newcastle coalfield was also the earliest scene of the genius of George Stephenson, whose first locomotives were constructed in 1814 for the conveyance of coals along the Killingworth colliery railway, and with the Wylam engine may be regarded as constituting the commencement of that modern railway system which has been developed in so extraordinary and rapid a manner.

A circumstance which appears anomalous is the very late introduction of railways underground, which did not take place in England until about 60 years ago, a century after their employment on the surface. But this may be to a great extent accounted for by what has been already noticed respecting the sinking of pits: so long as they were sunk tolerably close together, the necessity for improved means of underground transit was not felt; but after deeper pits had been sunk and the distance of the workings from the shaft became consequently greater, the system of sledging, carried out first by manual labour and then by horses, gradually yielded to an imitation on a smaller scale of the wooden railways employed above ground, which enabled a horse to drag two or three of the basket corves instead of one only. By slow degrees cast iron and ultimately malleable iron rails were introduced; and as the last improvement, the carriages conveying the coals were brought from the face of the workings to the surface "on their own foot," that is without changing the mode of transit.

Horses and ponies are chiefly employed for the purpose of underground conveyance, and minute calculations have been made of the expense of this mode of conveyance. On a descending gradient of 1 in 144, the rails weighing 22 lb. per yard, and the tubs carrying from 7 to 10 cwt. of coal each, a horse brings out 34 tons of coals per mile per day at a cost of 3·1*d.* per ton per mile, including haulage, maintenance of carriages and way, but not interest on capital of construction. The gross weight of a train in this case was 6½ tons, the weight of coals being 4 tons and the weight of the carriages 2½ tons. On the contrary with an ascending gradient, now rarely tolerated, the expense has been known to amount to 8*d.* per ton per mile. In either case the use of underground railways is a great improvement upon the previous sledge system, under which a horse's performance was not more than one-tenth of its present amount. But a cheaper mode of underground conveyance is still wanted, the cost being on the average three or four times as much as that by railways on the surface. In cases where coals are to be brought from distant workings, a steam engine placed at the bottom of the pit is sometimes employed; with an endless wire rope where the way is level, or double ropes where the gradient is sufficient to enable the empty train to overhaul the rope: and in this case the cost has been brought as low as 2*d.* per ton per mile. The self-acting inclined plane, first introduced by Mr. Barnes at Benwell Colliery near Newcastle in 1797, is also employed underground, an application for which it is peculiarly suited owing to the naturally inclined position of the strata.

With regard to the ventilation of mines, the agent employed for this important purpose in the Northumberland and Durham district is a rarefied column of air, heated by an underground furnace, or in a few cases by a furnace and chimney at the surface. The mechanical conditions established by the rarefaction can readily be calculated, as they depend upon the mean temperature and corresponding weight of the expanded or upcast column of air compared with the weight of the cold or downcast column of air of the same length; the motive or ventilating power is thus easily ascertained. In the case of Haswell Colliery near Newcastle, for example, the observed mean temperature of the upcast shaft is 163° Fahr., and that of the downcast may be taken at 50°. The depth of the upcast shaft is 936 feet; and the weight of the upcast column of air of this length at 163° is the same as that of a column of 766 feet length of air at 50°: the expansion of air for each degree Fahr. being $\frac{1}{490}$ of its volume at 32°, or $\frac{1}{508}$ of its volume at 50°. Hence the column of air in the upcast shaft would stand if cold at a height of only 766 feet; and therefore the effect of the furnace is to lift the air through the further height of 170 feet, and this work is done upon the whole of the air passing up the shaft from the mine. The observed quantity of air passing through the mine is 94,960 cubic feet per minute of air at 50°, or 7407 lb. per minute, the weight of 1 cubic foot of air at 50° being ·078 lb. Therefore the useful horse-power developed by the furnace is 7407 lb. lifted 170 feet in one minute, or 1,259,190 lb. lifted 1 foot in a minute, which divided by 33,000 gives 38 horse power as the ventilating power of the furnace. The coal consumed in the furnace is 8 lb. per minute: hence the duty performed is 17,628,660 lb. raised 1 foot high by 1 cwt. of coal. This is therefore the actual result obtained with the ventilating furnace at Haswell Colliery. At Seghill Colliery near Newcastle the duty is only 5,573,333 lb. raised 1 foot high by 1 cwt. of coal: the quantity of air passing through the mine is 42,700 cubic feet per minute.

In both the above examples the rate of duty obtained with the ventilating furnace is low: and it may indeed be regarded as a remarkable circumstance that purely mechanical appliances have been so little used for ventilating mines. The writer is not aware of a single example of ventilation by mechanical means in the two great coal mining counties of Durham and Northumberland. Elsewhere mechanical appliances are in use for ventilating mines, and amongst them may be mentioned Struvé's mine ventilator, several of which are employed in the South Wales colliery district, at the Eaglesbush, Dyffryn, Risca, and other collieries. This ventilator is shown in Plate XXII. Fig. 1 is a vertical section, Fig. 2 a plan, Fig. 3 a sectional elevation. The air is drawn from the mine by means of a pair of large aerometers, A A, made of boiler plate and similar in construction to ordinary gas-holders, each working up and down in a circular chamber of brickwork B, the bottom edge of the aerometer being immersed in an annular trough of water C, in the walls of the chamber. At the top and bottom of each chamber are two sets of air-valves, I and O, consisting of simple wooden flaps hung upon vertical gratings, which open inwards on the side I communicating with the pit, and outwards on the opposite side O. In the up-stroke of the aerometer, the air from the pit D is drawn in along a passage E, and enters below the aerometer through the bottom inlet valves I, while that above the aerometer is expelled through the top outlet valves O. In the down-stroke the air below the aerometer is expelled through the bottom oulet valves O, while more air from the pit is drawn in above the aerometer through the top inlet valves I. The two aerometers are worked by cranks at right angles to each other, thus rendering the draught of air from the pit practically uniform.

Up to the present period the various machines employed for ventilating have not supplied the same quantity of air as is obtained by the underground furnace in well laid out coal mines, where the air channels are maintained in proper condition, and are of an area in no case less than 40 square feet. However satisfactorily therefore some of these machines considered separately may have worked, they do not at present offer sufficient reasons for superseding generally the furnace ventilation. They are also liable to derangement, an important feature not applicable to the furnace; for even if the fire be extinguished, the heat of the upcast shaft is still sufficient to cause the circulation of a free air current for some days. The simplicity of its construction is also a great argument in favour of the furnace; which thus continues with all its inconveniences to be the principal ventilating agent for mines.

The labours of the Mining Institute of Newcastle may be expected to conduce to the improvement of the ventilation as well as of the drainage and working of mines; and may probably be the means also of developing principles the importance of which cannot at present be appreciated, whether as regards economy of production, or security against those terrible explosions of fire-damp which continue to be the bane and reproach of modern mining.

Before the introduction of the safety lamp, mines liable to issues of fire-damp were lighted by the steel-mill: by means of

Digitized by Google

toothed wheels a rapid revolution was given to the steeled rim of a wheel, against which a piece of flint was at the same time held, and the stream of sparks produced was sufficient to give at least a feeble degree of illumination. The principle of this mode of lighting depends upon the circumstance that the fire-damp or light carburetted hydrogen requires the contact of flame for its ignition, and is not fired by merely incandescent substances or by very small points of flame. In this respect it differs from either hydrogen gas or the other compounds of carbon and hydrogen.

The coal mines of Northumberland and Durham, which had so small a beginning, are now, according to an estimate based upon returns made to the coal trade office, drained and worked by 443 steam engines, representing 26,740 commercial horse power. The production last year was nearly 16 million tons of coal, being one quarter of the total product of coal raised in Great Britain. If in the absence of accurate statistics a similar scale be assumed for general application, it will be found that the total coal production of Great Britain employs nearly 2000 steam engines, of an aggregate of 120,000 commercial horse power, but representing the actual work of about 300,000 horses: a singular contrast with the still recent period when two solitary pumping engines lifted the water from mines on the banks of the Tyne.

NOTES OF THE MONTH.

The Atlantic Cable.—A correspondent writes,—"As the distance between this country and America is so great, it is very desirable that the electric wire should be surrounded by the best possible non-conductor; glass being by far the best non-conductor yet known, if it can be effectively applied will consequently be the best material to employ. As generally used glass is of course exceedingly brittle, but when spun into thread becomes sufficiently pliant to allow of being wrapped round the hand, perhaps even round the finger, therefore there appears no reason why it could not be wrapped round the wire in a long spiral, the machinery employed by Silver and Co. for wrapping the india-rubber thread, might perhaps by certain alterations be made to wrap the spun glass thread instead, and thus equally well enable us to obtain a more effective non-conductor than either india-rubber or gutta-percha. The covering of spun glass might then receive a slight coating of caoutchouc cement, and then be efficiently protected from the water by Silver and Co's. coating of india-rubber. The india-rubber coating from its closeness being more impermeable to water, from its elasticity less liable to strain or breakage, and from its powers of resisting heat, appears as a non-conductor of electricity decidedly preferable to gutta-percha."

Harbours of Refuge.—Votes are required this year of £34,000 for Dover Harbour, £75,000 for Alderney, and £65,000 for Portland Harbour and Breakwater. The works, the *Times* remarks, are progressing satisfactorily, although to whose satisfaction is not stated.

Monument to David Cox.—The Birmingham Society of Artists are taking the initiative in a movement for providing a monument in memory of the late Mr. David Cox, the artist. It is proposed to place the monument in Harborne Church.

Railway Bridge for short spans.—At a recent meeting of the Franklin Institute, a model of a bridge for short spans, in use upon the Mine Hill and Schuylkill Haven Railway, was exhibited. It is simple in design, and not expensive. The righting of the bridge is done by means of struts, which abut at the middle of the span, and have their lower ends resting upon plates inclined towards each other, and set against the abutments. These ends stand some distance apart, and are kept from sliding down the inclined plates by a bolt passing through both. By screwing up the nut of this bolt, the struts approach each other and move up the inclined plates, when the abutted ends rise, and with them the cross timber of the bridge. Also a working model of a switch lever used upon the same road, in which the catch is moved by a supplementary lever operated by the act of grasping the main lever, in the mode adopted for the starting bar of marine and locomotive engines.

The Greek Slave.—The statue of the Greek Slave by Hiram Power, was recently sold to the Duke of Cleveland, for 1800 guineas.

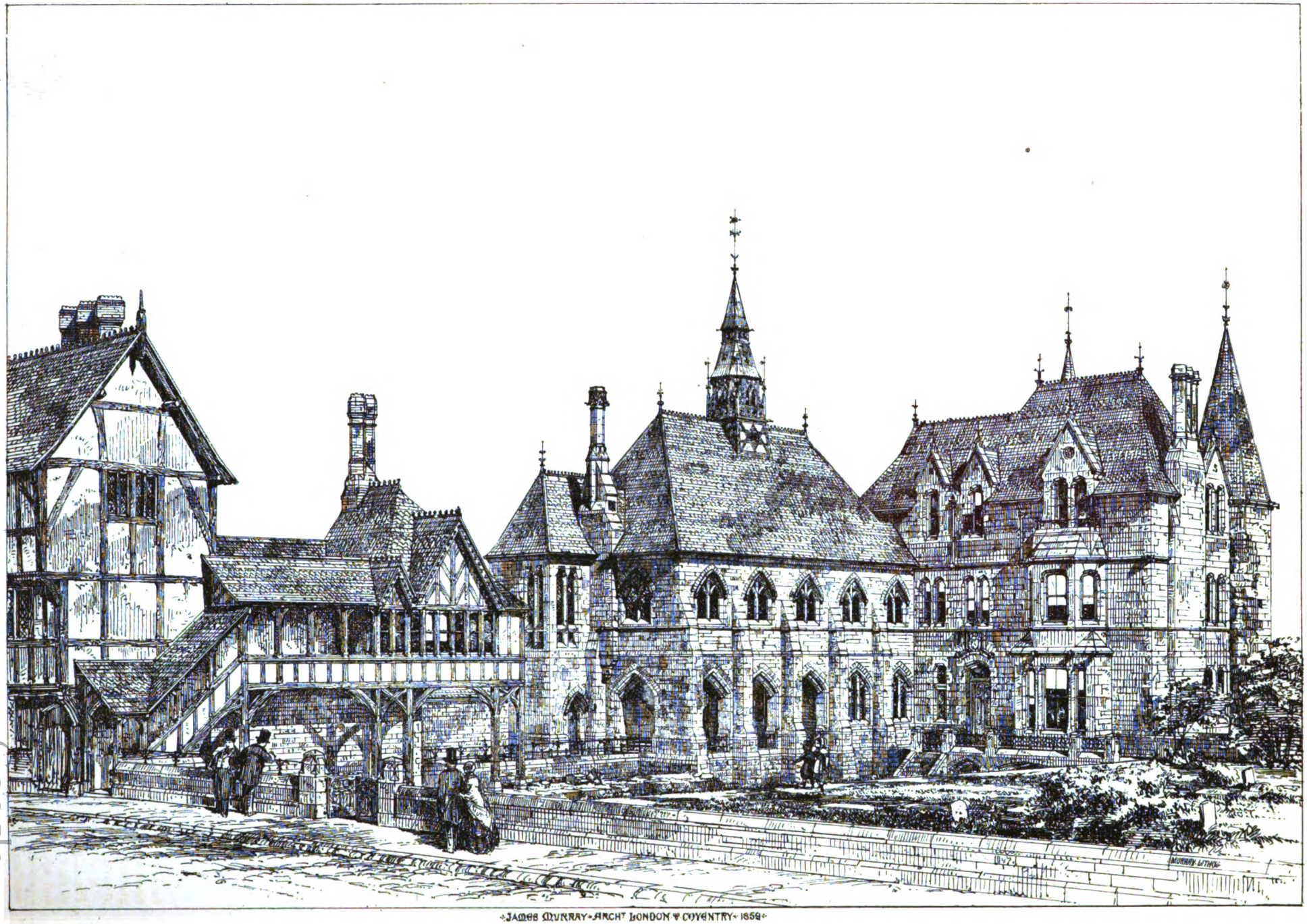
The Charing-cross Railway Bill has passed the Lords. It was decided that the line will be most advantageous to the public, that there was no preferable plan before the House, and that compensation is to be made to St. Thomas's Hospital as the law directs. The site of the station is to be Hungerford Market. The bridge over the river will be upon the piers of the present suspension bridge, and the line will then connect the Waterloo station of the South-Western with the London-Bridge station of the South-Eastern.

New Westminster Bridge.—Within the last two months all the cast-ironwork of the arches has been fixed and bolted together, with the exception of the arch from No. 1 pier, which will be completed with the rest in the course of a fortnight, and only the short wrought-iron ribs in the crown of each remain to be lowered into their places to complete the bridge for the formation of the roadway for the western half. Two of the Surrey-side arches are quite finished, and have their wrought-iron portions bolted in, and over all the other arches the roadway has begun to be formed on the cast-iron portions. The roadway is formed in the first instance by laying down a sheeting of wrought-iron "buckle" plates, which are 7 feet long by 4 broad, and rather less than ½ an inch thick. The peculiar form of these plates gives them immense strength on their convex sides. One was tested with a block of granite weighing not less than 17 tons, and after remaining under this ponderous mass for nearly a week, there was not the least sign of permanent compression. The ribs of each arch are placed at a distance of 5 feet apart, except in the two footways for passengers, where the weight being trifling, they are fixed at intervals of 7 feet. Over these ribs the buckle plates are bolted down, the channels covered by the slopes between each being filled up with blocks of wood and asphalte, till the whole way is a perfect level. Over the asphalte, when firm, will be placed concrete to the depth of a foot or more, and over this again a stone paving known as granite "pitching," Mr. Page has cut away the abutments of the old bridge in such a manner as to allow the fixing of another rib, and by this means there will be a gain of 6 feet in width to the public on the opening of the western half, which will then be some two or three feet wider than the present bridge. He proposes when the first half is opened, and the old bridge sufficiently pulled down to permit the extension, to carry out a wooden footway, about 12 feet wide, on the east side of the bridge, and thus leave almost the whole of the permanent road free for carriage traffic. By the adoption of such a plan the roadway of the western half of the bridge alone would be wider than the whole of the old structure, footways included. Such a plan has been repeatedly proposed for the passenger traffic of London-bridge, in order to make the whole of the roadway and footpaths entirely available for the immense carriage traffic. The whole block of houses on the Surrey side, from Stangate-street to the foot of the structure, is intended to be removed, with the greater portion of the block beneath the Clock Tower on the Middlesex side, to form the approaches. When the first half is opened the completion of the second half will occupy but a comparatively short time—probably not more than from 12 to 15 months. All the piers except two for the east half are entirely finished, and ready for the reception of the bed-plates and iron arches. The pattern of the stone parapets for the new structure has been decided on. It is of granite, bold and highly ornamented. The amount of timber used in the bearing piles of the bridge is 45,700 cubic feet; of cast-iron in the foundation 1600 tons; and in the superstructure 2600 tons. The wrought-iron in the superstructure is 1300 tons, and in the foundation 70 tons for tie rods. In the other parts there are used 165,000 cubic feet of granite, 21,000 cubic yards of brickwork and Portland cement, and 30,000 cubic yards of concrete. These seem large proportions, though, for its size, New Westminster-bridge will be one of the lightest and cheapest bridges over the Thames, and beyond all question the strongest and handsomest.

Statue to the late Joseph Hume.—Mr. W. Calder Marshall, R.A., has just completed the statue to the memory of Joseph Hume, which is about to be erected at Montrose. The figure is represented as in the act of addressing the House of Commons. A small pillar, bearing the arms of the city of Montrose, supports the figure, which in other respects is perfectly free. The statue is 7 feet in height, and executed in stone, indurated with the preparation which has beeen applied to resist the action of atmospheric moisture in the stone of the new Houses of Parliament.

Digitized by Google

Digitized by Google



JAMES MURRAY ARCHT LONDON & COVENTRY 1859

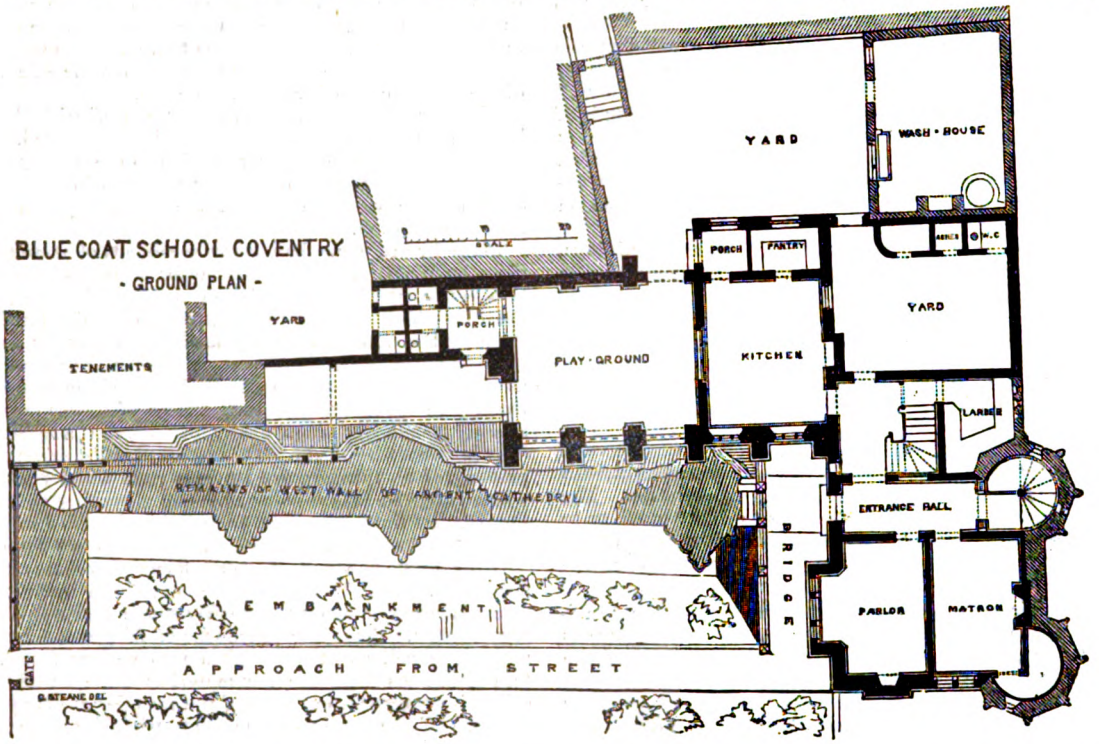
Digitized by Google

BLUE-COAT SCHOOL, COVENTRY.

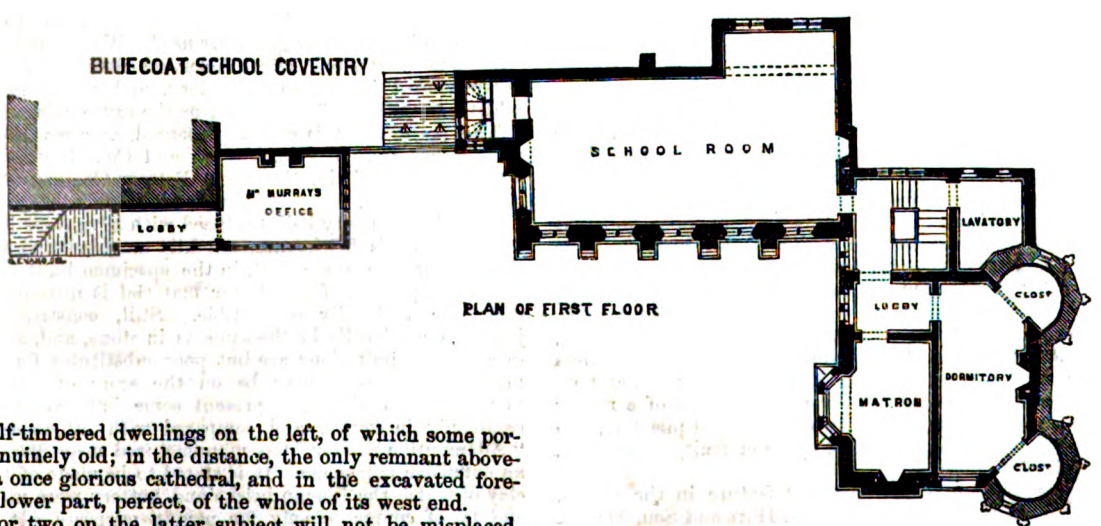
(With an Engraving.)

THE Bluecoat School, Coventry, is an ancient institution, one of the numerous charities which the venerable city of Coventry nobly supports. The building appropriated to its use has in common with others changed its aspect from time to time, as circumstances or taste have dictated. Some two or three years since it appeared as a simple unobtrusive dwelling, which a passer by would easily overlook, but now a variety of causes have rendered this locality one of the most interesting in the town. Standing where the spectator is supposed to do in our engraving, one direction points him to the group we here see, viz., the new Bluecoat School, and residence adjoining, the picturesque half-timbered dwellings on the left, of which some portions are genuinely old; in the distance, the only remnant above-ground of a once glorious cathedral, and in the excavated foreground the lower part, perfect, of the whole of its west end.

A word or two on the latter subject will not be misplaced. The cathedral whose remains have thus been but recently exposed to view has been minutely described in several old documents, and appears to have greatly resembled that of Lichfield, more especially in the disposition of plan and elevation towards the west end. Like that, too, it could boast of a tower and spire at the north and south extremities of this front, and also a central tower and spire of surpassing richness; so that when these three were co-existent with the two lofty steeples of Trinity and St. Michael's churches (which are in the immediate neighbourhood), the effect was very imposing. The cathedral was however, with the exception of the portion of the north tower before referred to, levelled by Henry VIII., who also destroyed an extensive Benedictine monastery which occupied the adjoining site.



Many efforts were made for its preservation, especially at the instance of the then bishop (Rowland Lee), who had been a confidential adviser of the king under many circumstances, but all of no avail. About 10 feet of the west end has been disclosed, exhibiting, in the jambs of the entrance doorways, and the responds to the nave arches, rich moulded and shafted details of early date, with walls of enormous thickness: the positions of these are indicated, with the remains of an old winding staircase in the angle of the south-west tower, on the plan. The north-west tower (or rather, as much of it as remained) has been pre-



Digitized by Google

served, and incorporated with the new building, which is partly erected (unavoidably, we believe) on the old cathedral foundations.

The school building, which with its central turret forms the principal object, is entirely new, and has been carefully studied with regard both to the situation and convenience of plan. The lower part is open, and serves as a playground; the main walls being carried on a series of arches, the piers of which are strengthened by buttresses. The whole of the upper floor is devoted to the school.

The house contains matron's apartments, the usual domestic offices, and dormitories for the children, which in this institution are exclusively girls. The rest of the general arrangements will be readily understood by reference to the plans. The walling is of the Coventry red sandstone, whose colour harmonises admirably with surrounding objects. The outlay has been about £2200. The timber buildings adjoining are additions to some old tenements, relics of that class of mediæval domestic work for which Coventry is so famous.

The schools, residence, and the new half-timbered buildings, were designed and erected under the superintendence of Mr. James Murray, of London and Coventry.

EXHIBITION OF BUILDING MATERIALS, MANUFACTURES, &c., CONDUIT STREET, LONDON.

It was a happy idea, and one which has proved productive of many beneficial results, to associate a pratical department with the more artistic elements of the Architectural Exhibition. The close affinity between the two it is needless to dilate upon, or to point out the special advantage which scientific artizans and their clients may derive from the opportunities thus afforded for displaying and canvassing the merits of their several works.

Now that the picture "season" is over, and with it the Architectural Exhibition (distinctively so called), this one feature is retained, but amplified so as to occupy nearly the whole of the available space in the rooms, and the whole is open for inspection *free*. As may be imagined, several of the former exhibitors have retained their "space," and their show-stands present but little noticeable alteration: still, in the additions which catch the eye, the influence of the stimulating principle referred to is discernible, and will doubtless become more so on each successive occasion.

There is at present, however, one great drawback to the utility of this collection: we say *at present*, because it may yet easily be obviated,—it is this, that there is no catalogue of the different productions, nor have their proprietors in the majority of cases given the necessary information as to prices, modes of conveyance, fixing, &c. &c., which, in a commercial point of view, constitute important items in comparative calculations. We observe too, with regret, that several of our most talented operatives (we use the word legitimately) in various branches are not contributors. This should not be the case, and it will probably not occur when the next opportunity offers. Accordingly there is a manifest dearth of works of a superior class, those requiring artistic skill in manipulation. Of the higher classes of architectural design, and carving in particular, the show is poor; while in imitative substitutes, which give too true a reflex of the economic tendency of the times, there is an abundance, and that of the best kind. Messrs. Jackson and Sons, for instance, have brought their carton-pierre and papier-maché to a high state of perfection. Next in arrangement are some specimens in cement, papier-maché, and composition, by Messrs. White and Parlby, which include portions of work prepared for the Britannia theatre, Weston's Music Hall, and the Canterbury Hall; these, if less finished than the ones just mentioned, are very effective, and no doubt amply serve their purpose. As illustrations of a rather different kind, we may refer to the two ornamental pilasters, also exhibited by them, in which natural types of fruit, flowers, &c., are most truthfully imitated.

Metal work again forms an important feature in the rooms, and in addition to the stands of Messrs. Hart and Son, Messrs. Johnston, and Messrs. Cottam and Co., which remain pretty much as of late, we now recognise several tasteful specimens furnished by Messrs. Skidmore and Co. Among these may be enumerated reproductions of some of the elaborate brass furniture on the doors and other parts of the newly-decorated house of the president of Magdalen College, Oxford,—a compartment of the gate last fixed in Ely Cathedral, across the north aisle of the choir, which is an improvement on that by the same firm in a corresponding position on the south side,—a portion of an altar rail, in the ornament of which the sacred emblems are interwoven, and which appears rather heavy, and overladen with ornament,—several standards and groups of gas lights, a standard lamp (very good), and a quaint-looking fire grate—undescribed, but possibly belonging to the Magdalen College work—which is curiously planned, inasmuch as the front bars are made concave instead of convex. Besides these there is a show-case, empty as yet, but destined we presume to contain some select specimens of the higher class of ornamental design.

Messrs. Cox and Son retain their "space," with the articles we have in our exhibition notice already enumerated. It will be enough therefore to direct attention to the saving of time, and consequently expense, in finishing patterns in woodwork up to a certain stage with the help of the machinery which they now have in operation.

Close by are some handsome specimens of mosaic patterns in glass, by Mr. G. H. Stevens, who has for some years given his attention to the art of glass tesselation in stone, alabaster, marble, and the like. The mosaics are composed of stained and pot metal glass, and a new gold mosaic made expressly for church work; this is bedded in strong cement, rendering the mosaic as durable as stone or marble. This material has also been turned to another purpose in the inlaying of the surfaces of flower pots, or "jardinieres," rendering them really ornamental accessories to the drawing or sitting room. These glass mosaics, arranged in colour patterns of rich design, are let into pure white cement, and the whole is hardened and polished to one glistening surface. Inside the pots are lined with zinc, so as to be adaptable to receive soil, if necessary, or filled with water, to act as vases for cut flowers.

Of Arrowsmith's solid parquet floors there are again several specimens. This, though a somewhat costly luxury, has the recommendation of being thoroughly sound and substantial in its construction. Some fine specimens of Serpentine marble will be noticed, as well as others worked into various forms. For certain situations there are few materials more suitable, so far as colour is concerned, but some of the varieties are far preferable to others. Of the more useful marbles, where strength is an object, we may point to those from Devonshire and Derbyshire. Some chimney pieces near the entrance to the principal gallery are very fair samples of this material.

Gibbons' "door knob" is a very simple and clever contrivance, easily adjusted and fixed. From its mode of action it is not liable readily to get out of order. Tann's "reliance locks" also, which are manufactured by Messrs. Walters of Wolverhampton, display the utmost nicety and precision of workmanship. It is superfluous to say the same of those by Messrs. Hobbs. Ashley, and Co. Hart's (69, Fleet-street) gas-burner, an invention of the simplest kind, and easily applied to almost any tube, requires only to be known to be generally used. We augur the same with respect to the "patent safety Atlas gas-chandelier," one of which is suspended in the main gallery, and which indicates by a whistle the escape of gas as long as the cause exists.

The potter's art is well represented, as are various kinds of tiles, bricks, &c. Messrs. Minton and Co., Maw and Co., Eastwood, Fayle, Godwin, the Poole Pottery Company, and Blanchard's terra cotta, each contribute specimens worthy of examination, and which may be introduced with advantage into building works. Fayle's bricks are carefully moulded, and in colour so closely resemble stone that, in the specimen built in the north gallery, a portion of the latter material is introduced, and the difference is hardly perceptible. Still, constructionally, the jointings can hardly be the same as in stone, and, after all, these over-careful imitations are but poor substitutes for the genuine material, except it may be on the score of expense. Norman's ornamental bricks present some improvements on those commonly in vogue, and compared with others around. The "Adamantine clinker," too, manufactured near Stamford, boasts an extensive patronage. It is stated to be made of the identical clay of which the Roman bricks and pottery were manufactured, and is, of course, chiefly for paving purposes. It appears to have been extensively used in various railway stations, and public and private works, as well as by many eminent building firms and contractors. This clinker, which is manufactured by machinery, is superior to the Dutch in shape and colour, while it absorbs less than half the quantity of water. An analysis of the clay of

Digitized by Google

which it is composed was found to possess, it seems, the extraordinary amount of 69 per cent. of silica.

Of Moore's ventilators, which are well and approvingly known, there are two or three models: also Mr. Fox's silvered glass gas and day light reflectors,—a useful application. With these may be mentioned Bunnett's ventilating sashes, the working of which is contrived simply by perforations in the sash bars, which, by a sliding bolt can be opened or closed at pleasure.

Martin's cement is perhaps the most generally serviceable of its kind, especially for surface purposes internally. Scott's patent cement also possesses some advantages, it is well adapted for external use, and of a uniform tint throughout; there is said to be a saving, too, of 50 per cent. as compared with Portland, while it can compete with it in hardness within a short time of its application. As a material for receiving stamped ornamental patterns, in the way advocated by Mr. Ferrey, it is also found very suitable. The same agents, Messrs. Lee, Son, and Smith, also supply Scott's patent plaster, which, it appears, may be used with advantage. The examples on view are not, however, designed in the best taste. Bunnett's fireproof floors, and Taylor's patent bricks for hollow walls, &c., specimens of which may be seen in the north gallery, show marks of continued improvement: the filling in for the walls may be gravel, ballast, burnt clay, or the like. Wetterstedt's "patent metal" has now been for some years before the public. From its peculiar amalgamation, the much desired quality has been attained of resistance to oxidation or rust, acids, and the action of the sun and atmosphere. It has been largely used for roofing purposes, and has properties which render it preferable in many cases to zinc.

Kershaw's imitations of woods were referred to in our architectural exhibition notice: another candidate in the same line is Mr. C. Smith, of 43, Upper Baker-street, whose stained specimens are among the most perfect that can be imagined. Some preparations of asphalte are also to be seen here: that known as the "Polonceau" is carefully analysed. Messrs. Cooper and Messrs. Trundle retain their show of elegant paperhangings; and M. Desachy still occupies the end of the east gallery with his "composition" ornamental front to the boxes at the new Covent Garden Theatre.

Mr. V. Bellman, too, has some good scagliola specimens, and imitations of various marbles. An entirely new decorative material, termed Marmolite, is among the most attractive objects in the end room. It is patented, and applicable for plain or ornamental surface work, either internal or external. It professes to be incombustible, and is a cheap and effective substitute for real marbles, granite, porphyry, &c. It is said, too, to be a cure for damp walls. Manders' white Coburg varnish appears to be a real desideratum, being a perfectly clear and colourless copal. Mr. Magnus and Mr. North show in a few specimens what can be done with *slate* as a basis for ornamental purposes.

In sanitary inventions there is no lack of models and appliances. Those by Mr. G. Jennings are well known, and may here be readily examined. They include forcing pumps, self-acting water closets, drain pipes, and a simple but excellent apparatus called the "water waste preventer." In the same department are Messrs. Botten and Son's specimens, and Messrs. Hayward Tyler and Co.'s regulating valves, which are very ingenious inventions. Wright's patent self-acting water closet is deserving of mention, as also Lambert's model of a "cheap" one, and his double-barrel pump, and stand-post for street watering.

The exhibition will remain open for some time, and it is intended to be repeated in successive seasons.

LOCOMOTIVES ON COMMON ROADS.

THE plan has been again revived of introducing steam locomotive carriages on common roads, and a committee of the House of Commons during the last session examined witnesses with a view to ascertain its practicability. The experiment of road locomotives had not a fair trial when formerly made, for the formation of railways, and the obstacles that were presented to the running of such carriages, for the time threw the project into the shade, and after several ingenious engineers had been ruined in the endeavour to construct locomotives adapted to the peculiarities of irregular surface traction, the notion was abandoned. The trustees of turnpike roads also, having tried to render the locomotives inoperative by covering the roads with quantities of loose stones, at length adopted the more effectual plan of getting the tolls on such carriages raised to a prohibitive rate. One of the chief objects of the select committee on the Locomotive Bill, which was brought into Parliament late in the session, was to ascertain whether the objections to steam carriages or waggons arising from the injury to the roads and from the frightening of horses, had been overcome by Boydell's traction engine; and whether that method of travelling might not be revived by the application of his invention. The committee appointed to consider the bill met on the 19th of July, Mr. Garnett being appointed chairman. They sat only for three days, and examined the following witnesses: Mr. William M'Adam, Mr. Gibson, Mr. Henry Browse, and Mr. Fredrick Hemming, when the preamble of the bill was agreed to, several amendments were made, and it was reported to the House.

The evidence given by Mr. M'Adam, the general surveyor of turnpike roads, was highly favourable to the traction engine, and he communicated the notes he made during an experimental journey with it from Thetford to London in May last. The importance of the subject will justify our quoting amply from his evidence, omitting those portions that had no immediate bearing on the question, and omitting also the questions of the members. Mr. M'Adam said:

"Up to the year 1857 I was perfectly convinced that locomotives could never travel upon turnpike roads, but I was then induced to see how they were constructed with what is called an endless railway; my curiosity then led me to look at it, and when I saw it I was so satisfied with the mechanical construction of it, that I saw the company, and requested that they would give me an opportunity of travelling with an engine, so that I might see the effect of it, both as to draught and as to its effect upon the road. They allowed me to do so, and I went to Thetford, and accompanied the engine with a load of some 30 tons, I think, and brought it into London. That is the only engine that I have ever seen at work. I promised the company, when I went down, that I would keep a log of the proceedings of the engine, and let them have a copy of it, and also any observations which I might make upon it; but not being a professional engineer, I merely suggested some things, and made amateur observations. My principal object was, to see what the effect of the engine was upon the road, and how it was enabled to draw so great a weight as they said it would draw. I had previously gone much into the subject with several gentlemen who had suggested engines years before; I had talked a great deal to Mr. Brunel about them, and the conclusion which I always came to, and which Mr. Brunel said was a correct one, was that the resistance of the road to the engines which were then suggested was so great, that there would be no balance of power left to draw the carriages.

The thing that struck me as being so excellent in Mr. Boydell's contrivance was, that the resistance to the forward motion of the engine was entirely destroyed by making the engine travel on an iron rail for nearly a yard, and when the wheel arrived at the point of that rail it, in a most ingenious manner, lifted the rail it run over and laid down another for itself to run over. The bite which the engine had upon that iron rail was sufficient in most cases to propel the load which the engine had behind it, but where the wheel had a tendency to slip, the attachment of the wheel to the shoe was such that it could not slip any more, and the consequence was that the engine had the whole hold of the shoe upon the ground, and that shoe occupied an area of something like a thousand inches, so that the bite of the engine upon the ground was equal to the area of the shoe, and the wheel could not slide because the attachment prevented it, and in a most ingenious manner the engine continued to lay down one shoe after another as it wanted them.

If the Committee will allow me, I will suggest that there are two points that will arise before you, I think: the pressure on the road, and the injury by pressure to the road; the bite of the engine, and the injury by the bite of the engine: they are totally distinct things. This (*referring to the model*) is an iron rail, and that remains perfectly quiet on the road; the consequence is that let the load be what it will, the pressure on the road is diffused over the whole area of that shoe. The wheel then proceeds along the shoe that it has just laid down, lifts it up, and then lays down another. Now with regard to the power of the propelling carriages, if this wheel had no shoes upon it, then you would have the bite of the width of this wheel acting upon a point upon the road; if that were skidded it would break the road, but if not it would simply go forward, having previously tried to loosen the road, and perhaps, have loosened it to some certain extent. Here,

Digitized by Google

before this wheel can skid, it must drag the whole of that shoe along in that direction; and with enormous power and great resistance it does so.

I have here a copy of my journal of a trial of Mr. Boydell's traction engine on its endless railway; and by extra sized spokes, there was attached to this a projecting iron all the way round, with teeth upon it, facing upwards.

'The single power consisted of a pinion of ten teeth, working on the geared wheel of ninety-six teeth. The double power consisted of the same pinion working into another of twenty teeth, which worked into the geared plate before mentioned. The front wheels, which work on a fixed axle, and lock by means of a perch bolt, are four feet six inches in diameter. The endless railway was removed from them.

By these front wheels the engine is guided or steered by means of a coach pole of nine feet in length, and a wheel and rudder chains conducted exactly as it is on board ship, the pole representing the tiller.

'The extreme pressure of steam is 70 lbs. on the square inch. The first point of draught is in a direct line with the driving wheel, the second and usual point 18 inches towards the near side of the engine, both through a strong beam of wood, bolted to the firebox foot plate.'

The reason of that was that the engine in going forward very much resembled a boat pulled with one oar; if you had put a rope from a boat pulled by one oar, over on this side, your boat would go nearly straight forward, because the backward draught would counteract the oar.

'An elevating screw working in the perch bolt raises or lowers the head of the boilers according to the ascent or descent of the ground, and is easily worked by the steerer. It has 16 inches of thread. The load consisted of articles which were to have been sent to London by railway; and the train of carriages which contained them was necessarily elongated by the requirements of the general turnpike acts, which restrict the weight of goods which shall be placed upon two or four wheels. The train was 95 feet in length, the engine 27, making together 122 feet long. One timber waggon, 4½ inch wheels, 5 tons 7 cwt.; one threshing machine, 2 tons; one ditto, 1 ton 17 cwt.; one waggon on 2½ inch wheels, containing a spare supply of water (never used), coals, coke, iron castings, &c., 4 tons; one agricultural engine (which was left at a farm near Newmarket), 3 tons; eight people (three of whom were in attendance upon the engine and one on the train), chains and heavy attachments, to enable the waggons to draw each other, 5 cwt.; making together 17 tons 1 cwt. (That was exclusive of the engine; then my report states this:) On Thursday morning left Thetford at 10.3; supply of coke 10 cwt. 2 qrs. 12 lbs., ditto of coals (14 bags) 8 cwt. 2 qrs. 24 lbs.; tank full of water; one ton spare water. 10.5 a.m. started; 10.10 double power on in mistake, reduced to single. First mile, uphill, 1 in 24; 11.6 down hill, about 1 in 36, then up, 1 in 15; this tried the engine, the driver not being acquainted with her power; 11.15 stopped to show engine; 11.17 on again; 11.22, stopped at Elden for water; watered by a draw-well with a small bucket; 12.46 p.m. started round a right-angled turn in a 23 feet road without any difficulty; 1.15, stopped for horses.'

That means, stopped for horses which were frightened. We had met several cart-horses; they had noticed it a little, but not enough to require us to stop. On going down hill, if the hill is sufficiently steep to allow the load to overtake the engine, we then put the skid on to some of the wheels of the load; but if the hill is not sufficient for that, we then let them go down quietly, and the engine itself is retarded by reversing the engine or throwing it out of gear and letting it pump itself dry.

'At 1.16 we started; 1.43 stopped for heated driving-wheel (a new box had been put in that morning). The road had been loose, and made of flints; stopped for want of steam; coke had been tried, and smothered the fire; it was found to be too slow in burning; very bad parish road, but flat; 3.15, stopped for water at three-quarters of a mile from Milden Hall, Suffolk; cleaned ash-pan for first time; crowds of people and many horsemen, and some gigs following us, riding and driving close to the engine; 5.30, steep, bad road, over 1 in 18; engine very steady; about 2½ miles an hour; steering beginning to be affected at the inner or No. 2 point of draught; all this time single power used; 6.10, stopped at the 'Red Lodge' inn; filled up water, 3½ miles from Milden Hall; cleaned fire-pan; 6.35, started from the 'Red Lodge;' road very good, dry, hard, and smooth; 7.36, crossed railway arch up a gradient of 1 in 15, newly stoned with broken flints. The engine went very slowly, but did not stop; would not steer well; tended to the near watercourse, and at last got into it. I stopped the engine to alter the power, when Mr. Boydell desired the single power might be continued, and he would get us out of the difficulty by altering (for the first time) the point of draught to that in a direct line with the driving-wheel, or No. 1. The engine then went on, steering quite well, and got out of the watercourse; 8.15, arrived at Newmarket; went through the town, and left the train in a wide part of the road; returned to the town with engine, and placed it in the yard of the 'Half Moon,' a most awkward place to go into or out of with two horses in a waggon, as the entrance is narrow, crooked, and of a steep ascent. The engine went in and out without the least difficulty, although there were not 6 inches to spare at two points of a crooked turn. This distance is 22 miles, in consequence of going round to avoid an insecure bridge on the main road. We started at 10.5 a.m., arrived at 8.15 p.m.; time, 10 hours 10 minutes. Deduct actual stoppages, 3 hours 55 minutes, less stoppages than would have been necessary had tanks existed, 20 minutes; actual mercantile time, 6 hours 35 minutes, which is equal to three and four-tenths of a mile per hour for one day. Coal used (including a little coke), 10 cwt. 14 lb., or about half a hundredweight to a mile. The coal was bad; the road generally on a rise, Newmarket being much above Thetford.'

No accidents happened to vehicles or to other things, except such as I have read. We had not on any one occasion to take hold of a horse. Once or twice, near London, I went forward for the purpose of holding some carriage horses, but the coachman told me not to do so, as he would be able to manage them; the horses just stared at us, and then went on. We never attained five miles an hour, and I think I mention at the end of this report, that according to my idea, they never should go beyond that speed with that sized wheel. I should say that those engines ought not to travel, and would not travel at a greater speed than four miles an hour. The Committee will bear in mind that I have taken no further interest in this engine than to ascertain what effect it would have upon the roads and upon loads, under an impression that it might some day come into operation. I believe that the engine has been most materially altered and improved since the time of which I have spoken, at the suggestion of various officers of the Government who have seen it.

(Journal continued)—'On Friday, May 15, 6 a.m., in Newmarket. Got up steam, and repaired the axles of the threshing machines, which, being of wood, were working badly all the day before; 7.15, started with the train; 7.56, a hill near the fourth milestone, nearly 1 in 19, the rest of the hill 1 in 12, about one furlong in length; not the least difficulty; two miles and a half per hour; road very good; 8.30, stopped at Six Mile Bottom for breakfast; filled up water; road good, but very undulating; the railway people telegraphed our starting from here up their line. The train was diminished in weight, by the loss of the agricultural engine of three tons. 9.15, started across the railway; road excellent, much downhill; stopped at Bourne Bridge for water; there being no convenient place to water, the engine was detached from the train, and turned at right angles down an embankment at 1 in 4; then on the bank turned again short to the right into the river, where, the tank being filled, the engine went through the stream, and up the other bank, into the road, and, backing on to the train, started at 11.33. (That was a very severe test.) The bottom of the river was very slimy; we forced it over a piece of waste grass, and there was hardly room at the end of the bridge for the engine to go by; the shoes tore away the bank of the field, cut a great hole, turned the earth up, and exhibited most extraordinary power; it did so much mischief to the bank that we offered to pay the farmer, who was present, for putting it right again; but he very kindly said he would not think of taking anything; 12.53, stopped for dinner at Chesterford, and filled up water; 2.13, started from Chesterford; 2.50, stopped at Littlebury to show the engine; 4.18, Newport; stopped for water; backed into a yard for it; stopped four times for horses.'

All that country, it will be remembered, is very uninhabited, except on passing through the towns; we passed through several towns. Generally speaking, when we came to the towns we were inconvenienced by the number of people who were riding round us; we had forty or fifty people riding round us in one of the towns, and I was afraid one of them would be struck. Some of the horses made a great objection at first, but the gentlemen coaxed their horses up to the engine, and the thing ended in every one of them following us. The stoppage of the engine removed the difficulty. We never had anything to do but to stop the engine, and then if a horse was frightened his rider would get down and coax him. The engine puffs off its steam like a locomotive, but the noise is not so loud. It struck me that the shoes on the wheel were the things that the horses did not like; they appeared to me more to dislike the sight of those shoes than they did the noise of the engine. The horses I speak of were hunters.

(Journal continued)—'At 4.18, Newport; stopped for water; backed into a yard for it; stopped four times for horses. 5.3, went on; stopped very often to fill up water, fearing a want of accommodation. Windmill Hill very long and heavy, 1 in 15 in one place. 8.30, Bishop Stortford; put up for the night; turned off a 15-feet road at right angles with the whole train into the inn yard, which ascended steeply; stuck fast on a dungheap, the rear waggon still overlaying the turnpike road; put on double power and took in the whole train, dispersing the dungheap all round; a shout from the bystanders, who had made up their minds that she was fast for the night; broke the steering-pole, and had it fished with

Digitized by Google

iron plates. Saturday, May 16, 7.22 a.m., left Bishop Stortford; Spillbrook Hill 1 in 12; road broken; engine tended to near watercourse. Altered points of draughts, and went on. 8.20, stopped to change draughts back again, tightened bolts on engine and looked it over; stopped at Harlow Railway Bridge, took off engine and filled up water; took in 12 cwt. of good coal, 20 cwt. having brought us from Newmarket, 41 miles, less than half a hundredweight per mile; road excellent. Bishop Stortford to Harlow, six miles. Station-master said we had arrived in half the time they had allowed us to do it in. Put the drag on to the timber carriage before it had reached the top of the incline; the engine took it all over with ease, notwithstanding the drag. (I merely did that to try the power of the engine on that piece of road.) Engine-driver quite acquainted with work and the engine; all went on smoothly. Harborough to Epping, 7 miles. 12.20 p.m., Epping; watered and dined; road hilly and rough from Harlow, but hard and dry; weather very fine; the road telling on the shoes.'

That is a point which I will explain to the committee. In the shoes which we travelled with, instead of this bar being laid in the direction of the route, it was laid a little out of the direction of the route; I never could quite understand the reason for that, except that the attachment being outside, the shoe might not come perfectly square down; but when it came to lift the bar underneath, here, it was taken upon this point (*referring to the model*), and just as it left the road it gave a slight scrape upon the road. I was obliged to watch very narrowly to see what it was that had brightened the iron; that was a mechanical defect in the making of the shoe; it was not a necessary consequence of the principle of the construction of it. I think that this contrivance (*referring to the model*), as far as I can judge from merely seeing it, will entirely get rid of it, but I have never seen this wheel at work; I felt in my own mind that I could have got rid of it myself if I had made the shoes.

(Journal continued)—'The consumption of oil and grease very great. (I should mention that it was in consequence of the heating of the boxes; they were put in in a hurry the morning we started, and they were not perfectly true; it was a mere mechanical defect.) 1.37, started from Epping, taking one passenger, who was anxious to see the engine work; left the engine at a pond to water, when the men without orders put on a new finger in lieu of one broken; took in water; one tank full had brought us nine miles of very bad road. The road through Epping Forest and into Woodford very bad; no level; gradients from 1 in 18 to 1 in 40; the road broken up all over, sandy and heavy, with half-settled material (round flint gravel, unbroken); 5.20, started from Woodford; 5.25, at bottom of the hill in the street, engine stopped, and on coming up to it saw two teeth broken out of the geared wheel, and the backward shoulder of the shaft saddle broken off beyond the bolts; 5.45, changed to the double power to ease the saddle; the bolt of the lever of the double power came off; there I left the train, within 200 yards of its destination, which was to be at Stratford. It was supposed the accident was caused by a momentary riding of the shoes from an improper bend in the new finger, but this was not confirmed by the engine-driver, who must have felt the shock; he only saw the tooth fall, and then the bit of the saddle fall at his feet on the foot-plate. The crank shaft was slightly bent at the same time, yet nothing appeared to derange the motion of the engine. The road was good and slightly down hill, and on a turn. I was looking at it from a short distance, but did not perceive any peculiar motion. The heels and toes showed the effect of 85 miles of flint road, and one end of each rail was worn at the corner. The fingers were in some instances indented, but I do not think the actual loss of iron as much as would have been incurred on the shoes of the 14 horses it would have required to draw the train. There was not any perceptible wear in any other part of the engine. The coals averaged half a hundredweight per mile, and the pace averaged three miles and a half an hour. It would not be well to allow one of these engines to exceed five miles an hour. There was much less difficulty in descending hills and turning corners with a long train than was anticipated.'

That is the whole of my report, which was merely intended for the company, and not for actual publication. I sent a copy of it, with the permission of this gentleman, to Colonel Tulloch, who had charge of the carriage department at Woolwich, and he sent an officer to follow an engine which the company made for them, and I think that his report was very much like mine, the same kind of incidents happening all through."

Mr. M'Adam was subjected to a long examination by different members of the Committee, for the purpose of eliciting further information on the points referred to in his journal. The most important parts of the information thus given were the following:—

"I saw one of these engines at Salisbury the following year, working a plough; and afterwards, at the Royal Agricultural Society, I saw it undergo a severe trial in the plough field. The principal part of the ground had been ploughed a day or two before. They got into a small hole in the ground, which was caused, I believe, by some chalk having been taken out; the waggon dipped into it, and the engine could not pull it out, the shoes tore up the soil and then the chalk, and the engine was very likely to bury itself. Mr. Boydell came to us: I was on the water tank: he took off the attachment and put on a long chain; the engine then lifted itself out of her own hole and got on to firm ground, and then it tore the tank, loaded as it was, out of the hole, and went up to the top of the hill.

The horse power of the engine on the journey from Thetford was ten horses nominally. The effect of the wheels upon the road was, that the moment the shoe moved from the undue pressure on the piston, it then began to scrape the road, and did that kind of mischief which a horse's feet do when he struggles.

I am of opinion that the damage which an engine and carriages drawn by the engine would cause to the road would be considerably less than would be caused if the same weight were drawn by horses.

The bursting of an engine is a matter so entirely out of everybody's control, that I would not say that the public would be perfectly free from danger of that kind; but it would be one of those points that the Board of Trade would have to look into very narrowly. The frightening of a horse is not, I think, a matter of so much consequence as should prohibit the use of these engines. I think that the use of them will obtain some day or other, and I think that some day or other the horses will become accustomed to them. We found that at first railways were a great nuisance to horses, so much so that in the General Railway Act power was given to the Board of Trade to order a screen to be put up for the protection of public roads; during the early stage of railways I was excessively particular about that, and insisted on screens being erected; some of those screens have since worn out; other railways have been made since, and I have endeavoured to get screens put to them; but the very gentlemen who had been in the habit of using the road have said that they did not want them; and I think myself, and I know from experience, that horses have become accustomed to railways, and I think that they would become accustomed to these engines in the same way; besides which, it is quite possible that the engines may be made much less objectionable than they are at present, by housing the wheels."

The remainder of Mr. M'Adam's evidence was directed to the consideration of the tolls that should be charged on such locomotive engines, and to the restrictions to which they should be limited as to use of wheels, speed, and general construction.

SUBMERGENCE OF TELEGRAPHIC CABLES.

We are compelled by pressure of other matters to reply as briefly as possible to the communication of Messrs. Longridge and Brooks in our last number, in which they object to the review in our January number of their paper read before the Institution of Civil Engineers, in February 1858.

After some prefatory remarks, they say "it is with some surprise that we read the assertion of your reviewer that Prof. Airy had dissented from our conclusions during the discussion at the Institution. We did not remember the expression of any such dissent during the discussion." They then proceed to support this assertion at some length. On this point we shall content ourselves with quoting their own admissions on previous occasions, without comment.

In the report of the discussion in question published by the Institution (p. 144), we find that Mr. Longridge replied to Prof. Airy and referred to the results presented by him to the Institution as follows:

"Mr. Longridge agreed that it was only by mathematical investigation that a correct conclusion could be arrived at on this important question. In closing the discussion on this subject on a previous occasion he had stated that the paper by Mr. Brooks and himself was based upon such an examination, the formulæ and calculations being given *in extenso* in an appendix. It was desirable that the mode of obtaining the results now recorded should also be placed before the members, in order that a comparison might be instituted. It might seem presumptuous in him to hint a doubt as to the accuracy of the mathematics of the Astronomer Royal, for whose attainments he had the most sincere respect; but from an anxious desire to arrive at the truth, he should wish that comparison to be made; as he could not but think that *the difference in the conclusions* could only arise from the neglect in one of them of some of the conditions of the problem."

Again, in a letter which Mr. Brooks addressed to us, dated January 18th, 1859, the following passage occurs:—

Digitized by Google

"You may perhaps doubt the correctness of the pamphlet when both your reviewer and Prof. Airy condemn it; but for your own satisfaction I may state that Prof. Airy had not read the mathematical portion of it, and when he made his remarks referred to by your reviewer, he had calculated only the form of curve that a cable would assume when the resistance and friction of the water are both neglected; of course a most erroneous hypothesis to argue from. From that hypothesis he went to the other extreme," &c.

In the face of these several admissions of Mr. Longridge and Mr. Brooks, it appears to us, that their denial that Prof. Airy dissented from their conclusions, evinces at least considerable courage.

The next objection to our review is summed up (paragraph 17) as follows:

"The bisection of the angle [the inclination of the cable to the horizon] is shown by us to take place whatever may be the *tension* at the bottom, provided that the cable be laid without *slack;* and is not, as your reviewer states, a necessary condition of laying the cable without tension."

The answer to this is very simple. The cable cannot be laid without tension at the bottom unless laid without slack. That this was our meaning is clear from the words with which we concluded the paragraph objected to—"which is obviously the only case in which the cable could be laid without coils, and without tension at the bottom of the sea."

The next objection is very disingenuous. Referring to the "centrifugal force" which exists if the cable move in a curve, we said—

"Now this centrifugal force the authors have neglected, and have in effect treated the sum of the normal forces as zero. This error, if there were no other, would in our opinion deprive their investigation of the value of an accurate demonstration."

The reply to this is (paragraph 19),

"The so-called centrifugal force has no effect in altering the form of the curve, but simply increases the tension by an infinitesimal amount."

Now, a similar result to this was arrived at by Professor Airy for a *particular case* of the problem after elaborate investigation, and he terms the result a "singular result" (*Phil. Mag.*, No. 104), as it certainly is. Our authors now announce that the result is true in all cases. Our strong impression is that it is not; though we confess that we have not at present arrived at a demonstration on this point. If the authors have obtained such a demonstration, they had better favour the world with it, and knowing as we do the analytical difficulties of the problem, we must say that such a demonstration would give us a much higher opinion of their mathematical abilities than we have at present. But why were Messrs. Longridge and Brooks quite silent about this "centrifugal force" in their original paper? Why do they now notice it for the first time, after having seen the investigations of other writers in which it is carefully taken into account? The fact is (as they perfectly well know) they entirely overlooked this important point when they wrote their paper read at the Civil Engineers' Institution. If there can be any doubt of this being the true state of the case, the following remark in Mr. Brooks's letter to us of January 17th, 1859, disposes of that doubt conclusively.

"The centrifugal force which he mentions has nothing whatever to do with the problem, and does not enter into Prof. Airy's investigations. As to the reviewer's 'opinion' in this paragraph, it is a mere *ipse dixit*, unsupported by facts or reason."

The next objection, paragraph 22, relates to the manner in which we criticised the authors' investigation of the "general equation to the curve assumed by the sinking cable." Among the errors of this investigation, we noticed that in one equation of the investigation the inclination (A) of the cable to the horizon was treated as constant, and in integrating that equation as variable. The authors reply that the integration is, if not exactly, at least approximately correct. Now it is quite true that there are certain cases in which a variable nearly constant may be treated as constant in integrating, and the result will be a correct first approximation; for instance, this method is adopted in investigations of the pendulum. But the authors here misapply the method. They deduce from the integrated equation that, in a particular case of it, it "is the equation to a straight line" (p. 36). According to their own showing they ought to have added to these words the word "nearly." Then what becomes of their demonstration? They set out by assuming that A is nearly constant, and the curve nearly a straight line; and then, after a frightful quantity of mathematics, arrive at the conclusion that the curve is a straight line nearly. A grosser instance of reasoning in a circle is not often to be met with.

Another blunder, equally glaring, in the same investigation is as follows:—In the integrated equation just spoken of, the constant of integration is evaluated by arbitrarily assuming a value for the inclination of the curve at the bottom. This value is such that the cable must be taken to be there either horizontal or vertical, and yet immediately afterwards the authors deduce from the result that in a particular case the equation is that of a straight line inclined obliquely. So that this remarkable straight line is in one part vertical or horizontal, and at other parts oblique!

The few paragraphs following that just noticed involve only matters of verbal criticism, and as we wish to confine attention to the scientific matters only, we pass on to paragraph 29. In the review we pointed out a discrepancy between the conclusion in problem 3, that the cable is a straight line, and the statement at page 9 of the paper "there is no reason *à priori* for concluding that the line of the cable is straight. Indeed, a little consideration leads to an opposite conclusion." The authors now get over this difficulty by saying that the passage just quoted "is the mere expression of what might at the first glance be *expected* to take place," and they say that, instead of "leads us to an opposite conclusion," they should have written "*seems to lead us*," &c. This is ingenious.

We stated in the review that at page 36 it is erroneously assumed that "the friction along the cable varies as the square of the velocity of the ship only." This the authors designate a wilful mis-statement. Whether it be so or not will appear from the following quotations from their original paper:

Page 34. "v = the velocity of the paying-out vessel."
" "m' = the co-efficient of friction at the velocity v."
Page 36. "m' is a function of $v = q'v^2$."

Here m' is distinctly asserted to be proportional to v^2, that is, to the square of the velocity of paying out; whereas we objected (and we repeat the objection) that m' ought to be proportional to the square of the relative tangential velocity of the cable in the water.

In paragraph 34 we are said to have falsely accused the authors of supposing the case of a "small plane disk" descending in water, and of "assimilating the motion of a small inflexible disk to that of a long flexible chain." The authors observe that they said not one word about a "small plane disk." Of course not: had they done so our argument would have had no force. Their equations are those of the motion of a disk, and what we complained of was, that it was supposed that such equations could represent the motion of a long flexible body. Really, no knowledge of mathematics is required to settle this matter. The authors have assumed that the cable falling freely through the water would descend like a straight rod uniformly. We, on the other hand, say that it is not right to assume that a flexible body left to itself would descend freely in the water, without bending and without rotation. It is clear that to establish their proposition the authors should have demonstrated that the equations for a flexible and inflexible body are the same.

Our correspondents cannot understand why an oblique rigid rod cannot descend freely in water with uniform velocity without rotation. We will tell them. Suppose first the resistances to be only normal, and that the vertical motion has become uniform. Then the horizontal components of the resistances, being unopposed, produce horizontal acceleration. Therefore the horizontal velocity is variable. Therefore the motion is not rectilineal as the authors suppose.

If, however, the tangential friction be taken into account, it remains for them to show that the horizontal and vertical velocities become uniform simultaneously. It is clear from the above consideration that this will not be the case when the effect of the tangential friction is comparatively small, and we know experimentally that it is very small for water. The rod might descend uniformly when vertical or horizontal; but the authors assert the possibility of such motion for every assignable inclination of the rod.

The truth is, the whole investigation is utterly and hopelessly wrong. If the authors had perceived the real difficulties of the problem, they would never have attempted its solution. The motion of a flexible chain in a resisting fluid is among the most difficult mechanical investigations that can well be imagined, and one can scarcely forbear a smile at the innocent unconsciousness with which these authors encounter difficulties which the most profound mathematician would deem insuperable.

With respect to problem 6, we stated that our objections were

Digitized by Google

conjectural, as we were not certain whether we understood it. Notwithstanding paragraph 38, which refers to this problem, we unaffectedly declare that we cannot make out its meaning. It refers to the form assumed by a "flexible line stretched across a current." We do not know what is the direction indicated by the word "across," nor what is the plane of the catenary which the line is supposed to assume. If the authors had made a distinct statement that the cable, under conditions clearly stated, actually assumed the form of a catenary lying in a particular plane, we could have dealt with the matter positively. But they made no such positive statement, and we therefore refrained from offering a positive opinion beyond this; that, as the effect of gravity is neglected, the investigation cannot apply to the submarine cable.

In paragraph 40 we are said to have misunderstood problem 8, which we objected to as a statical investigation of a dynamical problem. It is true, say the authors, that the words "suddenly stopped" occurred in the heading of the problem, but they do not occur in the body of the paper. Of course, we dealt with the problem supposing the authors meant what they said. The words are plain enough—"To find the form the cable will assume and the tension in case the paying-out vessel and the paying out should be suddenly stopped." Of this difficult problem the discussion was very brief, and did not involve a single dynamical consideration. But the mystery is now explained; the authors when they spoke of the vessel being suddenly stopped did not mean what they said, but were thinking of a mild problem in statics.

Lastly, in paragraph 41 the authors inform us for the first time that the quantity Rr in problem 11 measures the effect of a force to which not the slightest reference was made in the original paper—namely, the resistance of the breaks. The explanation removes one objection to the investigation of "the variation of the tension due to the motion caused by the waves;" but there are other objections to the investigation which show that a proper solution of the very difficult question involved has not been obtained. The motion of the vessel would produce a variation not only of the angular velocity of the paying out apparatus, but also of the velocity of the cable descending in the water. Both these variations would affect the tension; but of the latter of them no account is taken in problem 11. The remarks by one of the authors on this problem in their paper preceding it are very curious. He has some wonderful notions about the "catenarian form" and the "catenarian strain" as he calls them, which are introduced on every opportunity. They are thus introduced in the remarks on this problem.

"It is true that the vertical rise of the ship's stern would to some extent call into action the catenarian strain, but only so far as the paying out was influenced by the causes just mentioned. If the paying out was retarded, or even entirely stopped, the only effect on the cable would be to increase the abscissa of the catenary by the amount due to half the height of the wave, an amount quite inconsiderable in proportion to the whole catenarian strain, in such depths as from 1000 to 2000 fathoms," p. 21.

Only one page further on we are told that the stoppage of the paying out would, under some circumstances, "bring an ultimate strain of 7 tons upon the cable." We cannot help thinking that the author of the Appendix has a right to complain of his colleague for getting him into trouble. The difference between the two writers appears to us, that the former has a superficial knowledge of mathematics, and the latter has not.

ON PHOTOGRAPHIC ILLUSTRATIONS FOR BOOKS.*

By Prof. C. Piazzi Smyth, F.R.S.E.

From the first appearance of photography, its capacities for replacing engraving have been often speculated on, and sometimes tried; nowhere perhaps with more success than in the remarkable work of a lady artist in Edinburgh, 'Scripture Animals,' long admired by the public. These beginnings were worthy of all praise as far as they went, but that was unfortunately through so small a number of copies, that the "trade" lost heart in oxide of silver reduced by light as a material for replacing Frankfort black. Hence, both publishers and readers were rather inclined, after a lapse of several years, to hail the appearance of the "*Photogalvanographic Company*," who made photographs to engrave themselves on copper plates, and then printed from them in an ordinary press with indubitable ink of lamp-black and drying oil.

When this company was still sailing along before the breeze of popular favour, I commenced, with the assistance of Mr. Lovell Reeve, of London, the publication of a book on the results of my little astronomical experiment on the Peak of Teneriffe in 1856. Mr. Reeve, long known for his exertions in improving the illustrations of scientific works, jumped at the idea of availing himself of my stereoscopic photographs for the plates of the book, and opened a correspondence to that end with the company of the long name. Some brilliant examples of their method were sent, but we were both dissatisfied at the amount of hand work betrayed therein. Moreover, under the stereoscope lenses, the lines, dots, &c., white and black, by which the copperplate was made mechanically able to retain printing-ink, were odiously prominent; and finally, one morning in the middle of our deliberations the whole company was reported to have dissolved away, and left not a wreck behind; and with them disappeared for an indefinite period all chance of procuring copperplates engraved chiefly, if not wholly, by the action of light.

Hereupon Mr. Lovell Reeve threw himself boldly amongst the photographers, that is, photographic printers; and found that through the recent unexampled public appreciation of photo-stereographs, those professionals carry on their work now on such an increased scale, that he could reckon with a certainty on being supplied by them with a sufficient number of pure photographs of good quality to serve for a moderately popular book. He had almost arranged the terms, when he was taken aback by a letter from the chief operator, asking on whom the blame was to fall when any of the printing or original negatives got broken. These negatives were on glass plates necessarily; there were to be twenty of them for the book, and 2000 impressions of each, equal to putting one plate into a screw-pressure frame, and squeezing it violently 40,000 times. In some of those numerous squeezes, with levers and inclined planes to add to the grip, a plate must get broken now and then, and who was to bear the blame? The blame was not the point with Mr. Reeve, so much as the consequences to his book, from the source of its illustrations being destroyed; and he applied to me.

I therefore advised him at once to throw overboard all idea of printing from the *original* negatives, and to use secondary negatives only, or negatives made from the first through the intervention of transparent positives, also on glass.

This method promised many advantages:—1. The original negative need never be exposed to screw pressure at all; and if a secondary negative broke, it could immediately be replaced. 2. The printing of one subject could be carried on from several negatives of it, all working at once, and thus a large number of copies could be accumulated in a few days. 3. The second negatives might be made much stronger, so as to print more intense, and actually better, pictures than the original plates.

To insure the first of these conditions,—perfect safety to the original negative,—I constructed a copying camera (now exhibited) which, hooking on to the window of the operating room, and holding up the transparent negative against the light, made a transparent positive copy of it at the lower end of the box. Then copying the transparent positive in a similar manner, a new negative was produced, without one glass having to be put into contact with the other, or exposed to any sort of violence; and hence of course an indefinite number of these secondary negatives could be made one after the other, each capable of being used for printing on paper; and by nice adjustment of focal distance, the second negatives will be exactly the size of the first. They may also, as I have said, be made to print stronger than their prototypes; partly because there is a natural tendency in the photographic element, if a precise and peculiar length of exposure be hit upon, and then duly worked up by precipitation, to intensify differences of light and shade; and partly because the intensifying of an image once procured on a collodion plate can be carried on with more success in a regular operating room where the copying is being carried on, than on an exposed hill-side where the original view might have been taken.

From these circumstances I have been enabled, from a negative so faint that a professional photographer rejected it with disdain, to produce a copy as intense as anything that could be desired, the black part being perfectly black, and the white parts fully brilliant. This, too, has been accomplished, not only with faint originals intended for negatives, but with those vastly fainter ones still intended for opaque positives; and one of this latter class thus improved in the second copies, actually forms one of the plates in the Teneriffe book already mentioned.

* Paper read at the Royal Scottish Society of Arts.

Digitized by Google

This case is perhaps worth a little description, for many amateurs have got beautiful opaque positive collodions—*i.e.*, positives so seen by reflected light, and backed up with black varnish; and are generally told that such pictures cannot be copied or made to reproduce themselves. They may however, according to my experiments, be copied either as opaque positives by reflected light; or, a much better plan, as negatives, though of excessive weakness, by transmitted light, if the black varnish be removed. The removal, considering the hardness and density of the resin, might seem at first quite an impossibility; but that wondrous chloroform fluid of our eminent member Professor Simpson, effects the operation in a few seconds, and with perfect safety; for out of sixty specimens which had remained in the blackened state as opaque positives for nearly eight months, there was not one from which the whole of the varnish was not completely washed away by agitation in a dish with chloroform, and without any accident to the collodion beneath.

Far other results, however, attended sundry attempts to intensify the pictures thus restored to contact with the atmosphere, by applying silver solutions. The surface was, indeed, found strangely sensitive, considering the period that had elapsed since the almost momentary impression of light that formed the picture; but the precipitation was not very equal, and more still, the collodion on being touched with water floated off the plate. Out of seven cases tried in this way, only one proved altogether successful. Hence, in my further attempts, from very faint negatives to get strong positive copies, I was driven to depend solely on the peculiar power of photography to perceive and intensify minute differences of shade hardly appreciable to the human eye; and this natural principle proved abundantly sufficient for the purpose when employing the camera already described.

With these strong positives once procured, it is of course comparatively easy to take the remaining practical step, or to produce strong printing negatives by another somewhat similar copying process. The method which I have employed has been chiefly collodion, but I am inclined nevertheless to prefer albumen, as practised with such consummate skill by M. Orange, of this city. Having had a number of my pictures copied by him, I can compare the results of the two methods; and when the original is strongly pronounced, there appears no doubt that albumen forms the best material for a printing negative; for it is so hard as to need no varnishing, and indeed stands the work of the pressure frame far better than any varnish.

My present purpose however being not so much to describe a photographical process, as to point out both the practical possibility, and even advantages of printing from secondary instead of primary negatives, when large impressions are required for the trade, I will request attention to my work on 'Teneriffe,' recently published by Mr. Lovell Reeve. All the plates therein are from second negatives; while No. 18 is actually from an original that was a mere momentary impression, and was developed so as to form an opaque positive; and as such, covered with black coal tar varnish, it existed during many months. Application of chloroform then made it as clean and transparent as you now see it, with the appearance of a very faint negative of transmitted light. Used as such to print on paper, it gives only a very dark and most unsatisfactory picture; but twice copied on glass, with the precautions herein described, a second negative results, from which a brilliant paper print, inserted in the book, has been produced.

Several of the steps in this process are well known to photographers, but not all; and their application as a whole to the illustration of books seems not unlikely to extend the applications of photography; for Mr. Lovell Reeve informs me, that the chief or only drag now on the rapid production of copies for the public is the difficulty of getting experienced mounters. Each photo-stereograph consisting of two views, separately mounted or pasted on stronger paper carrying an engraved title, there are no less than forty mountings in the book, all requiring considerable nicety of execution. Yet as this is a mere affair of scissors and paste, it must yield to numbers, if the public keep up their encouragement of the idea; and in that case it may furnish a branch of industry eminently suitable to the young women of our closely-populated cities, and may enable them to support themselves by more remunerating labour than that of the needle.

So far what has been said applies to any size and arrangement of photographs. In the work in question the stereoscopic variety has been adopted; because, firstly, duplicate pictures enable one, where minute accuracy is of importance, to eliminate the little unavoidable spots and blemishes of the material, and prevent their being confounded with any features of the natural view itself; and secondly, the stereoscopic principle is such a wonderful acquisition to enable any one to appreciate not only the solidity but the distances of a strange landscape. Such pictures have not hitherto been bound up in a book; yet that will be found after all a most convenient way of keeping them, not unsuitable to the ordinary stereoscope open below, and eminently satisfactory with Mr. Reeve's new form, called by him the book stereoscope, which, for portability may be folded flat, put into a case like a map, and made to take its place on the shelves of a library.

In conclusion, we may thus recapitulate the essentials of photographic book-illustration, as worked out during the publication of 'Teneriffe.'

1. An original negative on glass, to be copied only by camera, so as to avoid contact with any hard substance.

2. Producing thereby one or more strong positives on glass, which being again copied on glass, either by camera or superposition,

3. Yield any number of secondary negatives, of the highest degree of power as to intensity of black and purity of white, for the service of the photographic printer.

THE VICTORIA (ST. LAWRENCE) BRIDGE.

(*Abridged from a communication.*)

THE present autumn will witness the completion of, perhaps, the greatest engineering work of our time: of that great bridge across the river St. Lawrence, of which the Britannia Bridge over the Menai Straits proves to have been but the precursor.

The directors of the Grand Trunk Railway of Canada having applied to Mr. Robert Stephenson, in 1852, as the engineer most competent to assist them, he considered the subject of so much interest and importance, that he determined to go out to Canada, personally, for the purpose of dealing with it. He accordingly went there in 1853, and after examining into the facts, concluded that a bridge across the St. Lawrence was practicable. On the 2nd of May following, Mr. Stephenson addressed to the Grand Trunk Railway Directors a report, in which he considered the whole question in three branches: first, as to the description of bridge best calculated to prove efficient and permanent; second, as to the proper site; and thirdly, as to the necessity for such a structure. Upon the first point he did not hesitate to recommend the adoption of a tubular bridge, as the description of bridge best fitted for a permanent, safe, and substantial structure in such a situation; on the second point, he was not a little influenced by considerations affecting the flow of the river and "those almost irresistible forces" consequent upon the breaking up of the ice in spring.

What is the amount of the pressure of ice four or five feet thick in a running stream of a certain inclination, velocity, and breadth? Mr. Stephenson first got at the inclination of the river; next at its velocity. He then assumed that the ice upon that river was what they told him it usually was, from 4 to 5 feet thick. He found that 9 miles above Montreal was the Fall of Lachine, which, of course, separated the ice above the fall from the ice below it. Taking these data, he calculated what would be the pressure* of 9 miles of ice from 4 to 5 feet thick, lying on a plane of a given inclination, and pressing against the piers of a bridge across the channel. The result of that calculation enabled Mr. Stephenson to arrive at the conclusion that "the almost irresistible force" of this mass of ice would crush or sweep away any ordinary bridge.

Mr. Stephenson decided on stone piers, each pier having, on the side opposed to the course of the stream, large cut-waters of solid stone work, inclined against the current, up which, as it were, the ice would creep, and break itself to pieces by its own weight and pressure. He arranged that these wedge-shaped cut-waters should present angles to the ice sufficient to separate and fracture it as it rose up upon the piers, but so obtuse as not to be liable themselves to fracture. These piers exhibit, as now constructed, every indication of massiveness and power to resist pressure, as well as of stability to support the superstructure. During the four years the structure has been in progress, it has withstood, in the most satisfactory manner, the violent pressures which have followed the break-up of the ice.

The superstructure is an elongated repetition only of the design for the Britannia Bridge. The Victoria Bridge is remarkable for its length, but its several tubes are not so long as those of the Britannia Bridge, and are only otherwise distinguishable inasmuch as that they are the longest tubes yet constructed without the adaptation of the cellular principle. These tubes were designed in the office of Mr. Stephenson, under the superintendence and supervision of his relative, Mr. George Robert Stephenson.

* This computation would be materially affected by the pressure of the ice against the shores of the river. Where it winds a large part of the pressure of the ice is sustained by the bank.—ED. *C. E. and A. Journal.*

Digitized by Google

ON THE GENERAL THEORY OF PROPORTION IN ARCHITECTURAL DESIGN, AND ITS EXEMPLIFICATION IN DETAIL IN THE PARTHENON.*

By W. Watkiss Lloyd.

I have undertaken this evening to render an account of the results of some studies of the principles of proportion in architecture as exemplified in the Parthenon.

The subject is not proposed as one of mere archæological interest, or simply as a curious chapter from the history of the art: if justice can be done to it, it ought to be something more—it ought to be a contribution to the scientific aids and resources of the art, as proving not merely that the Greeks worked upon such and such arbitrary maxims, but that they had discovered certain principles. To trace a theory of proportion as employed by the Greeks in design may be of interest in any case, but how much the more should it approve itself as having a rational and scientific basis.

Few here, it is probable, will doubt that the solution of one of these problems involves that of the other; and whoever can prove that he holds the explanation of the proportions of the Parthenon, will be easily absolved from further argument that the system employed was right and truly scientific; as on the other hand, a claim to possess a true theory would have to stand the test of application to the Parthenon. The general theme of admiration of all who write and all who speak of the impression of this temple on the spectator, I have found to be the sense of harmony that it excites—the pleasurable satisfaction of the feelings associated with proportion; grace of proportion, dignity of proportion, justness and harmony of proportion, are phrases that recur in the course of their observations again and again. In response to what is implied in these expressions, the speculative have not been remiss in asserting for architectural harmony as close a dependence on mathematics as has been so long established for musical. Admitting the justness of the presumption so far, I may say at once that my own conclusions are quite at variance with what is often the next presumption, that the ratios of the diatonic scale have any special value as realised in architectural forms. I do not find this to be the case,—I venture to say I find it distinctly not to be the case; but inasmuch as wherever numerous proportions are applied, on whatever principle, those which are found in the musical scale are sure to occur along with others, I can quite understand how the coincidences encourage a prepossessed or precipitate theorist, and flatter to betray.

It will be convenient to state succinctly in the first instance the most important conclusions, which will then be easily borne in mind through the process of proof and application.

First; it has appeared that the Greek architect attached the highest importance to the determination of his dimensions by proportion, and to the execution of those dimensions with minute exactness. Accidents and faults apart, for which a margin must be always allowed, nothing was left to chance, random, or remainder.

Secondly; dimensions are proportional, in the customary sense of the word, when they have a common measure; but it becomes of importance to decide in what directions they are most appropriately taken, which lines are architecturally characteristic. I find that the Greek architects brought into comparison dimensions measured along the same straight lines, or lines parallel, and such a comparison for convenience I call Rectilinear proportion; thus the height of an entablature may be commensurable with the height of a column, the breadth of a metope with the breadth of a triglyph, the height of a naos door with the height of a pronaos column. Another important form of comparison is between dimensions taken at right angles to each other, and such instances will be referred to as Rectangular proportions. Thus it seems obvious and reasonable to estimate the proportion of an oblong plan by comparative statement of the length and breadth; no doubt its form might be recorded and communicated numerically by the statement of the angle of its diagonal with a side; but the eye does not judge such a proportion by reference to the diagonal.

The comparison of length and breadth of the temple measured upon the top step, of the height and length of an apartment, of the height and breadth of a façade, or a triglyph, &c., are examples of rectangular proportion.

The direct comparison of areas I only meet with in one, but that a very important class of instances; I refer to the determination of the relative proportion of columns by proportion of their sectional area, a subject which space forbids me to enter upon.

Assuming it to be determined that no dimension shall be admitted into a design that shall not be proportionate to some other dimension, either rectilinearly, rectangularly, or both ways, it still remains to be considered what proportions or what ratios (using an equivalent expression) shall be adopted. Ratios even of low numbers exclusively offer themselves in crowds, and are to be subjected to arrangement and selection. If we commence with two equal lines, and leaving one unaltered, alter the other by continuous diminutions, we shall find every conceivable or possible ratio occurring between absolute equality, 1 : 1 on the one hand, and absolute disparity 1 : 0 on the other. If we pause at certain stages of the progress, as determined by some principle, these resting places will form a scale of proportion, a series of steps by which we may regulate degree of approach to and departure from equality between any compared dimensions or series of dimensions. On what principles are the resting places to be determined, the scales constructed? I can only give results briefly and partially too.

First; the design itself will necessitate the adoption of certain ratios from the requirements of purpose and plan.

Secondly; the variety of exigencies demand that the other selected ratios should range pretty widely over the interval to be divided, and give a choice of proportions verging towards inequality as well as towards equality, yet with sufficient interval to preclude confusing proximity.

Without pursuing the analysis further now, I must content myself with stating that the scale by which the Parthenon is regulated, commencing with the ratio 1:6, advances towards equality by ratios preserving the common difference between their terms of 5. Thus, 1:6, 2:7, 3:8, 4:9, 5:10, &c. As the scheme advances the differences become trifling, and the numbers undesirably high, and the scale is made out by the ratios 4:5, 5:6, 6:7, &c., the common members of a primary series. Such a scale is formed by the rejection of the innumerable other ratios, some self-condemned by their high numbers, but others as not required or as interfering with the effect of the most characteristic ratios. Thus, the ratios 1:3 and 2:5, are most extensively and importantly employed in the temple at Bassæ, but are absolutely unknown in the Parthenon. Even of the members of the scale admissible and admitted some are comparatively neglected, while emphasis is given to a few by repetition in many instances, and both rectilinearly and rectangularly, and in applications expressive and important. Such predominance we shall find to be given in the Parthenon to the ratios 4:9, 7:12 and 9:14—to the first especially. It is to be assumed that the system of making dimensions proportionate to each other, sometimes rectilinearly and sometimes rectangularly was adopted on the principle that the mind and eye naturally take cognizance of both forms of comparison, and feel satisfaction in both harmonies. What then, it may be said, are their comparative values when they clash? It was the aim and study of the Greek architect of the Parthenon that they should not clash, and we shall have to admire the dexterity and success with which he harmonised the two forms of comparison; so that rectilinear proportions that fall out as happily as if they had been exclusively considered, are found to be compatible with, indeed to be the means of bringing about, rectangular comparisons that are still more effective; but I leave it for the examples to bring home the value of this principle, and the skill evinced in employing it.

To the examples again I must trust for conveying due appreciation of the strict and logical consistency with which the Greek architect selected the terms of his comparisons; that the length of an apartment should be brought into proportion to its breadth, may be obvious enough, but in the ramification of design divisions are called for which must not be proportioned at random, but can only be correctly referred by a shrewd eye for correlative function and expression. Proportions to be expressive must correspond with and so represent natural relations of analogy or antithesis, and it was in the discernment or contrivance of these that genius founded and perfected Greek architecture.

The terms to which a prerogative importance is allowed in regulating other dimensions, are especially—1. The breadth of the front, from which is derived; 2. The breadth of the abacus; and, 3. The lower diameter of the column. But no subdivision of these into any moderate number of fixed minutes or modules will

* Paper read at the Royal Institute of British Architects.

Digitized by Google

explain their regulating power, which is dependent upon variable proportion, upon the adoption of ratios that may be taken from any part of the scale.

The designer of a Greek temple held it of importance to secure a definite proportion of low numbers between the length and breadth of the structure, as taken upon the grand stylobate, whether upon the topmost or on a lower step; a horizontal rectangular proportion. Thus the Parthenon has breadth and length on top step as 4 : 9, the Theseum the same but on the lower step, and the temple at Bassæ also on lower step has the proportion of 2 : 5, and the temple at Ægina that of a double square.

Equally important, or even more so was it that the full vertical height of the front, from the pavement of the peribolus to the apex of the pediment, should compare in a ratio of low numbers. In several hexastyle temples—those of Theseus and Bassæ are examples, and, I may add, the western front of the Propylæa—the height of the front is commensurate with the breadth as 3 : 4. In the Parthenon we shall find that, besides this grand ratio of height and breadth, which there is 9 : 14, very accurate rectangular proportions were obtained between other main divisions of the elevation; the check upon multiplying these in every instance was the stringent importance of certain rectilinear proportions which were liable to interfere with them. Of these it appears from comparison of examples, that the greatest importance was attached to making the height of the column exceed the joint height of the other members, that is, stylobate, entablature, and pediment, by a single aliquot. For example, the height of the column may compare with the complementary height of the front as 7 : 6, or as 6 : 5, &c. &c. In other words, the height of the column as compared with complement of height is the larger term in what is technically called a super-particular ratio. The ratio applied in the Parthenon is 10 : 9; in the Theseum 5 : 4, equivalent to 10 : 8. The Sicilian builders never discovered or appreciated this principle, and their effects suffer accordingly.

Thus much for the elevation of the front, but a farther arrangement was thought necessary or desirable in the Parthenon, in order to harmonize the column as vertical member with the joint horizontals, entablature and stylobate, as seen on flank, where from such frequented points of view the height of the roof was not visible or brought into comparison. Accordingly the joint height of the stylobate and entablature on the flank is just equal to half the height of the column; or say, height of column : complement on flank :: 2 : 1. With what exactness this is the case will appear from the comparison of figures to be given presently. The same ratio holds good in the same comparison in the Theseum, where the entablature received an addition of height from the cymatium, which, as discovered by Mr. Penrose, was returned along its entire length.

It was a further established principle that the height of the column should compare symmetrically with the horizontal spacing of the columns; should, in fact, be just equal to the dimensions from the centre or edge of one column to the centre or edge of a third, measured upon the plan. In the Parthenon this symmetry is applied to three ordinary columns and the two intercolumns included, and the same appears to be the case at Sunium. In the east front of the Propylæa and in the temple of Bassæ an angle column and columniation are included in the comparison, which, in the latter case at least, introduces a difference from the relative contraction of the angle columniation. In the temple at Rhamnus the dimension is taken from the outer edge of the angle column to the centre of the third from the angle; in the Theseum we have a like division, but involving only ordinary columns.

I apprehend that the introduction of these equalities of heights with breadths was found to give repose to the effect of a long range of columns, as a repetition of similar spaces and dimensions, and the principle may be susceptible of wide application, as in fenestrated compositions. If in the progress of a design we conceive the diameter and spacing of the columns to be settled in the first instance, it is clear that the principle just stated would limit the architect to choice of height among three or four fixed dimensions, and, on the other hand, if the height of the column is assumed, the systems of spacing that are available would be reduced within narrow limits. In point of fact, in all such cases no one point was settled absolutely until all others were settled. When the result is obtained it appears as if the adoption of one harmony brings about another as a necessary consequence, but this is not an accident, for the decision to adopt the first was made on the very ground that it was compatible with or involved a second; in all such adjustments the search is for those symmetries and proportions which recommend themselves by bringing the richest dower of subsidiary harmonies conducive to the effect required, and no solution is satisfactory until such are found.

One more principle, much taken to heart by the architects of the Doric temples of Greece proper, was to adopt a breadth for the abacus of the capital equal to $\frac{1}{5}$ of the height of the column, or else an aliquot part of the breadth of the temple on the top step, or lastly accommodating both conditions. A dimension for this part, however, cannot be adopted lightly, for it decides the diameter of the echinus at its greatest swell, and this must be relative to the general proportions required for the column. At Bassæ the abacus of the front is $\frac{1}{5}$ of the height of the column, but not commensurable with the top step; in the Theseum it is $\frac{1}{5}$ of the height of the column, and also $\frac{1}{12}$ of the top step; in the Parthenon the ordinary abacus of the east front is $\frac{1}{12}$ of the top step, but not commensurable with the height of the column; the abacus of an angle column however, which is broader than the ordinary, is equal in breadth to $\frac{1}{5}$ of the height of the column, while on the other hand it is, of course, no aliquot of the top step.

Such were the leading conditions to which by custom of the style, by experience of good effect, or by manifest fitness, the architect's design was bound to conform—which gave a certain guidance at the same time that they gave a certain control; not so much guidance that responsibility for ultimate effect did not rest with his genius, not so much control that genius had not ample range for variety and invention.

We have now therefore, in the case of the Parthenon, a clear breadth of front of 100 Attic feet, say 101·341, on which to erect an octastyle Doric portico, with diameters of columns proportioned to intercolumns in about the ratio 4 : 5, and in the distribution of the eight columns we have to take into account that, in accordance with the style, the angle columns are to have a somewhat larger diameter, and the angle intercolumns are to be somewhat more contracted than the rest. The process by which, it appears to me, the architect made the distribution in the present instance, is as follows:—The top step had to be divided into seven main segments, five of them being equal, and giving the lines of centres for six columns equidistant from each other, while the two end segments were to be somewhat larger, in order to receive the full diameters of the angle columns, a difference that more than makes up for the contraction of the angle intercolumniation. The problem therefore, in the first instance, is to assign the degree of excess to the two angle segments, as the breadth of the front divided by seven, after deduction of this joint excess, would give columniation. The seven segments of the step correspond to seven segments of the architrave, each equal, in a general way, to the breadth of two triglyphs and two metopes, except the external segments, which have to accommodate an additional half triglyph. Now, if we deduct the breadth of a semi-triglyph from each end of the step, and divide the intermediate space by seven, we shall find the divisions give us the ordinary columniations with the greatest accuracy. This process, of course, assumes that we know the breadth of the triglyph, and this may easily have been obtained before the average columniation was absolutely settled, as it is deducible proportionably from the breadth of the architrave.

Triglyph.	Columniation.	Ang. seg.	Measured.
101·341 − 2·786 = 98·555 ÷ 7 = 14·079 + 1·393 = 15·472			Cf. 15·478, 15·367
228·141 − „ = 225·355 ÷ 16 = 14·084 + „ = 15·477			Cf. 15·468, 15·449, 15·531, 15·443

We have now therefore obtained the centres of the columns, giving columniation 14·084, which is exactly coincident with a great many as measured, and also with the average of the variations, the principle of which is accurately determinable, but cannot be now discussed. If we divide this calculated columniation into nine parts, and assign four to the diameter and five to the intercolumn, we obtain, 14·084 ÷ 9 = 1·565 × 5 = 7·825, intercolumn; 14·084 ÷ 9 = 1·565 × 4 = 6·260, diameter. The measured diameters give 6·250 and even 6·245, and this may be held a sufficient approximation; still I believe that another principle decided the exact dimension adopted, though the difference may be but little more than $\frac{1}{8}$ of an inch. Again, we are entitled by the usage of the order to look out for an agreement between the height of the column and a division of the colonnade on plan. The nearest approximation is given by the dimension on plan that includes three diameters and two ordinary intercolumns, viz., 34·428, but

Digitized by Google

the height of the column is only 34·250, giving a difference of full two inches. Here again, while we are bound to admit that this approximate symmetry was regarded and valued, it is clear that we cannot accept it as governing the dimensions adopted in execution for the height of columns.

I will first go over the scheme of proportions by which I conceive this and the other divisions of the elevation to have been decided, and afterwards give the comparative tabulation of the dimensions as they come out by calculation, and as set down in the measurements of Mr. Penrose.

The proportion of the height of the front to the breadth of the top step is as 9 : 14. The breadth of the front is to the length of the temple as 4 : 9, as we have seen; and it is a necessary consequence of these proportions that the height of the front should compare with the length of the temple as 2 : 7. These therefore are the grand circumscribing proportions of the structure; the only inaccuracy is that the measured height of the front is half an inch higher than it should be by calculation; but the actual length of the temple compares with the height thus enhanced in the ratio 2 : 7, with absolute exactness within $\frac{6}{1000}$ of a foot.

2 : 65·1815 : : 7 : 228·147 Cf. measured 228·141.

It will be observed that the ratios, 2 : 7, 4 : 9, and 9 : 14, have respectively the common difference between their terms of 5. In the recited order the terms approach towards equality, and the series may be extended by insertion of intermediate and other ratios having the same characteristics, thus—

1 : 6, 2 : 7, 3 : 8, 4 : 9, 5 : 10, &c.

It will be found that several of these ratios are repeated with marked intention in the Parthenon, while none whatever are employed in the design that do not belong to the series either directly or as equivalents (as 2 : 3 = 10 : 15, &c.) The height of the front thus obtained is divided between height of column and of complement in the ratio 10 : 9, which gives 34·288 for the column, to compare with 34·250, the height of the angle column. From the complementary height we have now to deduct a dimension equal to half the height of the column, viz., 17·125, to be distributed between the stylobate and the entablature, so that the height of the column shall be just $\frac{2}{3}$ of the height from the level of the peribolus to the base of the antefixal ornaments on flank. The remainder of the complementary height belongs to the pediment, and proves just equal to the breadth of the ordinary columniation.

It will be observed, that it still remains to complete the horizontal division of the front by apportionment of dimension between entablature and stylobate. The problem may be stated to make such an apportionment that the rectilinear proportion adopted shall also bring about or be consistent with a certain number of very important rectangular proportions. On general considerations it may be easily determined to give a larger share of the dimensions at command to the entablature; but the question still remains, how much more? How much more precisely, and why? In effect the apportionment was made by giving 6 parts in height to the stylobate as against 11 to the entablature; the ratio 6 : 11, it will be observed, belongs to the series already specified.

The rectangular proportions conciliated by such division are these:—The joint height of column and entablature comes out exactly commensurable with the hundred Attic feet in the breadth of front in the ratio 4 : 9, which is the proportion of the plan; consequently, as the length of the top step is to its breadth, so is that breadth to the joint height of column and entablature.

Again, by the dimensions assigned by calculation, the breadth of the top step is commensurable with the joint height of column, entablature, and pediment as 12 : 7 nearly; by the addition,—by the adjusting increment, of $\frac{1}{2}$ an inch to the pediment the comparison becomes exact, with the further advantage of making the height of the pediment equal to one columniation.

Let us now compare the tabulated dimensions as furnished by Mr. Penrose's independent and scrupulous measurements which are accessible to all, and as deducible by the process I have set forth.

Hecatompedon.	Calculated.		Measured.
101·341 : 14 : :	9 : 65·1478 full height of front	...	65·185
30·859 :	9 : : 10 : 34·288 height of angle column	...	34·253
34·288 : 10 : :	9 : 30·859 complement of front	...	30·932

65·147 full height as calculated above.

Ht. of column.

34·288 : 2 : : 1 : 17·144 stylobate + entablature ... 17·150 on flank.
11·093 : 11 : : 6 : 6·050 height of stylobate ... 6·058
6·050 : 6 : : 11 : 11·093 entablature on flank ... } 11·092
i.e. + returned fillet of cymatium }
17·143 joint stylobate and entablature as above.

From calculated height of front ...		65·147
Deduct calculated entablature	11·093	
,, ,, columm...	34·288	
,, ,, stylobate	6·050	51·431
Remainder for pediment		13·716
Add height of fillet of cymatium only included in entablature on flank		0·299
Add increment as referred to above ...		0·037
		14·052 height of pediment 14·073
Entablature on front, calculated ...		10·794
Column, calculated		34·288
Height from pavement to apex calculated		59·134

101·341 : 12 : : 7 : ... ... 59·115 Cf. measured ... 59·127
101·341 : 9 : : 4 : 45·0426 column + entablature on front do. ... 45·046

With respect to the vertical division of the entablature, the frieze and architrave are made equal within a minute difference, which is given in favour of the architrave, and scarcely amounts to $\frac{1}{8}$ of an inch. The thickness of the horizontal cornice on front is derived from the height of the frieze by the ratio 4 : 9. It is therefore easy to divide the height of the entablature by 22, and assign 4 parts to cornice and 9 each to architrave and frieze.

Frieze 4·417 : 9 : : 4 : 1·963 Cf. measured 1·951

The perpendicular thickness of the raking cornice, with its cymatium at the apex of the pediment, is derived from the horizontal cornice, to which it is proportioned as 4 : 3.

I may add here, that the height of the capital is derived from the diameter of the angle column by the ratio 4 : 9, viz. 9 : 4 : : 6·378 : 2·834, to compare with measured 2·833. Again, the breadth of the triglyph is derived by the same ratio from the lower diameter of the ordinary column, viz. 9 : 4 : : 6·250 : 2·777. Compare measured 2·766.

The height of the stylobate is determined by the proportions of the elevation, but it still remains to assign a projection for its lowest step. The projection assigned, the joint breadth of the three lower steps is 4·997, which brings the following relations into harmony:—

5 : 4 : : diam. of ordinary col. 6·250 : 5·00 (measured 4·997).

Thus, the intercolumn is to diameter as diameter is to projection of steps—

6 : 5 : : 6·058 height of stylobate : 5·048 projection (4·997).

We cannot too highly appreciate the force and vigour that the composition gains by the feeling with which the artist has tempered the horizontality of the steps by the predominance of verticality in their profile. It is by the thickness of the stylobate exceeding its projection in the ratio of 6 : 5, while that of the column falls below the breadth of its correlative, the intercolumn, in the ratio 4 : 5, that it acquires an expression of superior solidity corresponding to its function of bearing the columns, though in reality of smaller dimensions than a diameter. The effect is assisted and enhanced by the steepness of the top step, the proper stylobate, as compared with those below. The height assigned to it seems to have been derived from the diameter of the angle column by the normal ratio 2 : 7, viz.—

7 : 2 : : 6·378 diam. of angle col. : 1·822 height of top step (1·814 measured).

We must now proceed to an abstract of the considerations of proportion which seem to have governed the distribution of the plan between peristyle, cella, and divisions of cella. The primary concern is to determine the line of the upper step, or proper basement of the cella, relatively to the parallel line of the upper step of the grand peristyle. The anta is placed at such a distance from the edge of the stylobate, that the sum of its breadth and the interval between it and a flank column exactly equals a columniation. To state this differently, the dimension including diameter of column on flank of anta, and interval between them, exactly equals the sum of the diameters of two adjacent columns on flank and the interval between them; and inasmuch

Digitized by Google

as the anta is less in diameter than a column the difference goes to enhance the interval or void. The process of division is, therefore, the simplest conceivable. Set off on the front from angle of top step a dimension equal to an ordinary columniation plus an ordinary diameter, say 20·34; this gives the lateral distance for the inner angle of the anta; assign a breadth to the anta which has a ratio to the diameter of column as 4 : 5, and this gives the outer angle of the anta, and the line of the cella step on flank.

The next and a most important consideration is the extent of the top step of the cella east and west; its distance from the parallel line of stylobate on either front. Here we find that by continued gradation, the interval between step of cella and edge of top step of grand stylobate is made greater on front than on flank—exceeds it in fact at the east front in the ratio of 8 : 7, being the exact ratio in which the interval from cella wall to flank column exceeds the intercolumn,

(viz. 8 : 8·920 : : 7 : 7·805 measured 7·818, &c.)
8 : 7 : : 17·138 : 14·997, measured 15·00.

The artist, however, who decided these proportions had regard at the same time to their compatibility with some others that are of the highest importance; the cella which was to be distributed among apartments that were required to have definite proportions could not have its length relatively to its breadth determined at random. Measured on the top step it has very exactly a ratio of breadth to length as 7 : 19; thus, 7 : 71·33 : : 19 : 193·61 which varies from measured length 193·733 on by deficiency of ·123, and this difference seems to be but the reappearance of the error 0·125 that we have noticed in length of the grand stylobate from just ratio to its breadth. The ratio 7 : 19 seems at first sight unhandsome and undesirable, from the high number it includes, and the great difference between its terms; indeed had the architect made the lower step of the cella longer by 0·68, it would have had the desirable proportion of 3 : 8, the change, however, involving a sacrifice of graces which he did not allow himself to be tempted to make. His justification and purpose became readily apparent. If we deduct an exact square from an oblong 7 : 19, we are manifestly left with an oblong reduced to the ratio 7 : 12, and this is the division which has been adopted. The breadth of the cella 71·33 is just equal to the dimension from the top step of the posticum to the back of the opisthodomus, including the thickness of the transverse wall of partition (71·334), and consequently the same breadth compared with the remainder of length, the dimension from the transverse wall in the naos to the edge of the pronaos step necessarily bears to it the ratio 7 : 12, the same ratio that occupies so important a place in the elevation of the façade.

I believe it to have been in order to help the value of this proportion, that the pavements of the naos and pronaos were made almost exactly upon a level, and thus, when the portal was thrown open, the spectator might easily take both dimensions together within the scope of vision.

From the stringency of the general proportions applied in the opisthodomus it is clear that we must expect at least equal care in the more important naos; it is also clear that whatever difficulties may have occurred in distributing the naos, they were overcome not by sacrificing the proportions of the opisthodomus but by effectually reconciling them. But by this distribution the plan of the proper opisthodomus itself is brought out with depth and breadth very accurately proportioned, as 11 : 16. The clear interior breadth on level of the pavement is 62·570 (viz. 4·380×2=8·760+62·570=71·330), and the corresponding depth as shown on plan is 43·003. Now 16 : 11 : : 62·570 : 43·016, a result which may be considered absolutely identical.

The uncertainty that exists, from the condition of the ruins, as to the height originally assigned by the architect to the interior of the naos and of the opisthodomus, hampers our investigation of the considerations by which he decided the distribution of the plan.

I have shown that the architect divided the platform of his cella by a transverse line, which gave an exact square for partition wall, opisthodomus, and posticum, and an oblong of the proportion 7 : 12 for the naos and pronaos. Assuming the thickness of the flank walls to be determined, the clear interior breadth of the apartments is given, and it remains to place the walls of the door jambs on either front at such distances from the wall of partition as to afford plans for the apartments of desirable proportions, and also leave fitting remainders for pronaos and posticum. Accordingly, the pronaos wall is so placed as to make the length of the naos 98·095, which compares with the sheer breadth from wall to wall of 63·01, in ratio 14 : 9. That is to say, the ichnography of the grand apartment,—of the naos, has precisely the same ratio between its dimensions, taken rectangularly, that obtains between the breadth of the temple and its full height on front from pavement of peribolus to apex of pediment.

14 : 9 : : 98·095 : 63·06 (measured 63·01).

This is a third example of a repetition of a special proportion, rectangularly on plan and on elevation, and in positions corresponding in relative importance; the former being 7 : 12, and 4 : 9. The thickness given to the pronaos wall equals the breadth of an abacus, and it happily results that the dimensions from the pronaos wall to the line of lowest step on front is exactly double that from the edge of cella step to the same line of the stylobate returned on flank.

It seems to have been a traditional principle that the hecatompedom, or 100 feet, which as we have seen measures the breadth of the temple, should also apply to some manifest dimension of the naos. To the naos specifically the title Hecatompedæan is found ascribed in inscriptions, and we need not look far to find a coincidence as near as the nature of the case would require. The dimension from the back wall of the naos to the centre line of the threshold measures 101·470, to compare with the exact estimate of 101·341.

I have now reached or rather exceeded the limits allowable for a paper. I am bound to observe that it is due to these limits that I have only been able to exemplify the theory by a selection of instances, and that there is not one application of proportion adduced that I cannot support by conclusive parallels in other Greek works. Although it is only in the Parthenon that all the refinements of the system are employed in all their perfection, yet each appears elsewhere separately, and so distinctly as to leave no doubt as to its recognition. These corroborations therefore I have been obliged to pretermit, for the same reason that I have avoided discussing rival systems, and the examination of the extent to which they involve truth, and the points at which as it seems to me fallacy supervenes.

ON WATERGLASS, AND ITS APPLICATION TO THE ARTS AND MANUFACTURES.*

By Frederick Ransome, C.E., Ipswich.

The articles upon the subject of waterglass, by Dr. Fuchs, and the recent report of the commission of the French government on the experiments of Professor Kuhlmann, would lead to the conclusion that the important subject of silicification and the various applications of soluble glass are comparatively unknown in this country, the more so, as no reference whatever is made either in the report or the articles in question to English discoveries and manufactures dependent upon the same principles.

As the inventor and patentee of various processes, in every respect analogous and almost identical with those suggested in the article alluded to; as having, during the last fifteen years, occupied myself exclusively in modifying and improving the manufacture, and applying successfully on a large scale, the soluble glass to various useful purposes previously unknown in this country, I may be allowed to claim the attention of the Society of Arts to the great injustice of bringing so prominently forward as a novelty, in so important a scientific journal, the history and results of experiments conducted by foreign chemists in the manufacture and use of a material for which *I received the Telford Medal of the Institution of Civil Engineers, in* 1848; *a Prize Medal from the Jury of the Great Exhibition in* 1851; and which I have been manufacturing at the rate of many tons per week at my own works, and more lately at those of the Patent Siliceous Stone Company, at Ipswich.

My own attention was first directed to the subject in the year 1844, when carrying out a series of experiments with a view to the production of an artificial stone suitable for grinding, building, and ornamental purposes, which should possess all the advantages, and be free from many of the defects of the natural stones hitherto in use. I found that with few exceptions the hardest and most durable stones were those containing the largest proportion of silica, and I at length succeeded in producing a compact stone by combining or cementing the particles of siliceous sand by means of a siliceous paste or cement, for which I secured

* From the Journal of the Society of Arts.

Digitized by Google

Digitized by Google

CONSTRUCTION OF BREAKWATERS

Fig. 1.

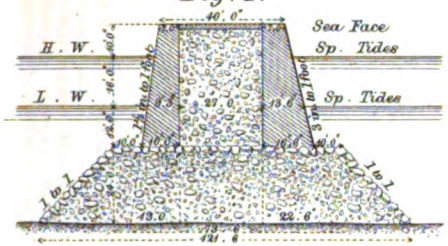


Fig. 2

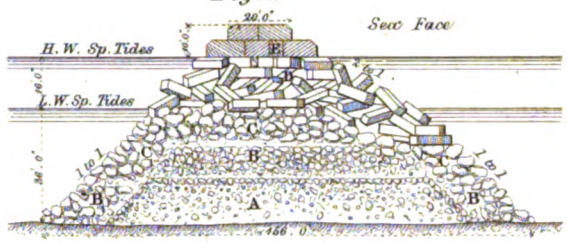
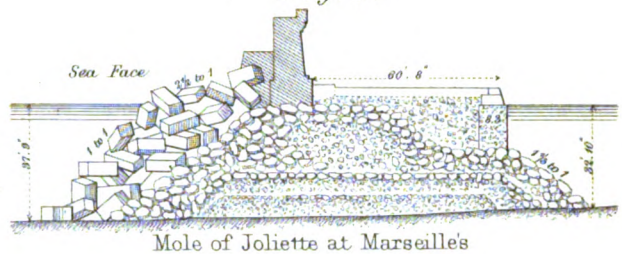
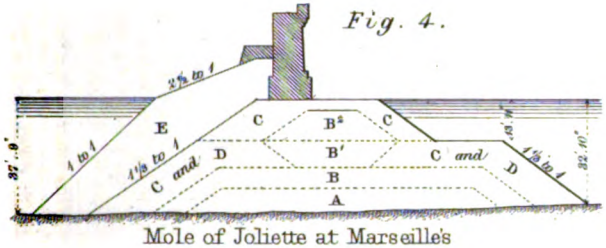


Fig. 3.



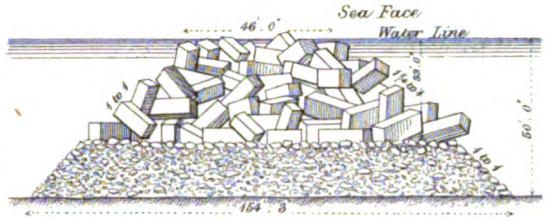
Mole of Joliette at Marseilles

Fig. 4.



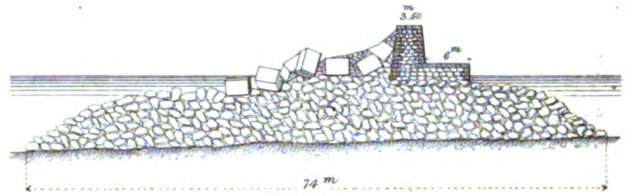
Mole of Joliette at Marseilles

Fig. 5



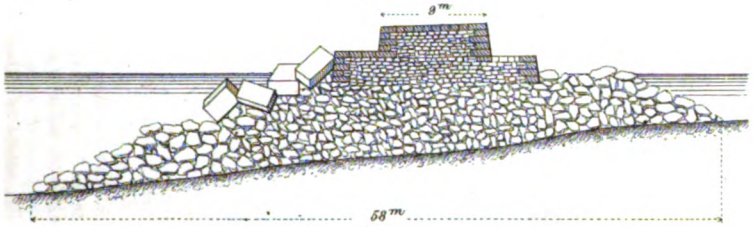
Mole at Algiers

Fig. 6.



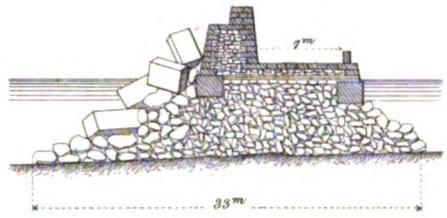
At Cette

Fig. 7.



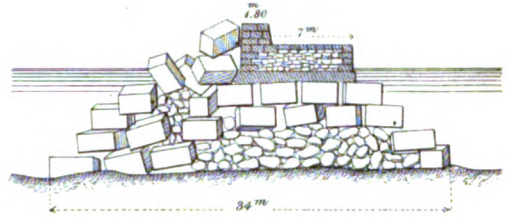
At Cassis.

Fig. 8



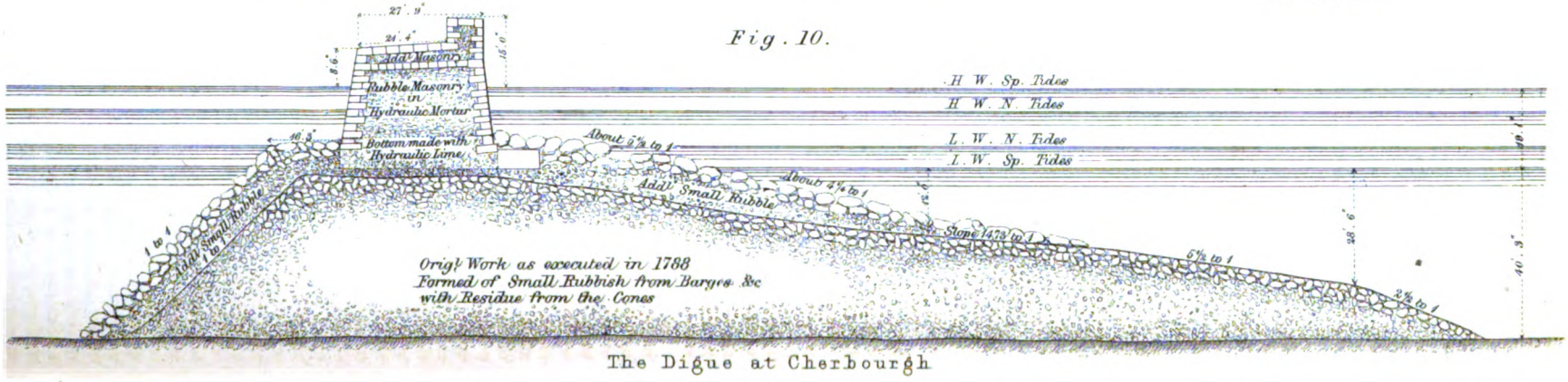
At Ciotat

Fig. 9.



At Vendres

Fig. 10.



The Digue at Cherbourgh

Sep^r 1859

J.R.Jobbins

Digitized by Google

a patent bearing date 25th of October, 1844. In preparing this siliceous paste or cement, I first dissolved soda or potash in water, which I rendered caustic by means of lime. Then, under the influence of steam pressure in an iron boiler, I dissolved broken flints in the caustic soda or potash until I obtained a silicate adapted to the purposes required. This silicate I afterwards mixed with the requisite quantity of sand, broken stone, or other siliceous matter, which, after being moulded into the desired form, was placed in a kiln and raised to a bright red heat. By this last operation, the soluble silicate, by combining with additional silica, was converted into an insoluble compound, and a stone was produced resembling, both in appearance and characteristics, the best descriptions of natural sandstone.

I was not at that time aware of the memoirs published by Dr. Fuchs, in Kastner's Archiv. for 1825; nor of the further researches either by him or Professor Kuhlmann; nor have I yet learned that either of those gentlemen attempted, or even contemplated, the manufacture of stone by such process; but on the other hand, I may be allowed to state that I secured a patent in France for this very process in the year 1845.

I soon however discovered that owing to the presence of a portion of sulphate of soda, an efflorescence of this salt was likely to take place on the surface of the artificial stone thus made when exposed to the weather, which greatly diminished the value of the article in its application to architectural and ornamental purposes; but it was not until the year 1853, after many discouragements, and a series of experiments involving a large outlay of money, that I discovered the means of preventing this efflorescence by the use of a solution of baryta; and thus succeeded in perfecting the manufacture of an article which has now received the approval of some of our most eminent architects, chemists, and geologists.

In the year 1845 I obtained letters patent in England, Scotland, and Ireland, for the application of a soluble silicate for combining small coal into blocks, and for preserving wood from fire and decay.

In the year 1854, and still without any knowledge of the work done by Dr. Fuchs or Professor Kuhlmann, I invented a process for "preparing oxides and carbonates of lead or zinc," "and carbonates or sulphates of barytes with soluble silica," either with or without being "mixed with colouring or other matter," and enrolled a provisional specification, intending to complete the patent for the same, but owing to an attack of illness I was prevented from obtaining this protection.

In the year 1855 I claimed and obtained a patent for further improvements in the manufacture of artificial stone; and lastly, in 1856, I invented and patented a process for preserving natural or artificial stone and other building materials, and rendering them less liable to decay. At this time I was made aware that a soluble silicate of potash or soda had been for some time past employed upon the continent for the purpose of preserving the stone of some public buildings; but I found in carrying out my operations, that although this process had been favourably reported upon in France, and that, under certain conditions, an apparently satisfactory effect was sometimes produced, yet it was nevertheless very imperfect. The general results, as obtained by the application of the simple silicate in our own country, being very uncertain, it appeared to me that one great cause of failure arose from the fact that the silicate being applied in a soluble form it was liable to be removed from the surface by rain, or even by the humidity of the atmosphere, before the alkali of the silicate could absorb sufficient carbonic acid to precipitate the silica in an insoluble form. But another great and serious defect in this process still existed, viz., that even were it possible to effect the precipitation of the silica, still it would be simply in the form of a gelatinous hydrate possessing no cohesive properties in itself, and therefore capable of affording but little (if any) real protection to the stone. It seemed to me therefore necessary not only to adopt a process which should ensure an insoluble precipitate independently of the partial and uncertain action of the atmosphere, but that to render such a means efficient, a much more tenacious substance than merely precipitated silica must be introduced; and in the course of my experiments I found that by the application of a second solution, composed of chloride of calcium, *a silicate of lime* would immediately be produced, possessing the strongest cohesive properties, and perfectly indestructible by atmospheric influences.

The mode of application is simply this:—The stone or other material of which a building may be composed should be first cleaned, by the removal of any extraneous matter from the surface, and then brushed over with a solution of silicate of soda or potash (the specific gravity of which may be varied to suit the nature of the stone, &c.): when dry, this is followed by a solution of chloride of calcium, applied also with a brush; the lime immediately combines with the silica, forming silicate of lime in the pores of the stone, whilst the chlorine combines with the soda, forming chloride of sodium, or common salt, which is removed at once by an excess of water. Experience has shown that when the silica is once applied to the stone in this manner, it is impossible to remove it unless with the surface of the stone itself.

The application of this process, which I also patented in France, in March 1857, has in every instance in which I have operated been attended with the most satisfactory results; decay has been prevented in the softest and most friable stones, and where disintegration had commenced prior to its use, this has been at once arrested, and the same stones rendered perfectly hard and durable.

Amongst other buildings which have been satisfactorily treated by this process, I may allude to the Baptist Chapel in Bloomsbury, the Royal Pavilion at Brighton, and the Custom-house at Greenock, in each of which buildings the stone which before was seriously decomposed is now hard, and I have every reason to believe is permanently preserved; whereas I am not aware of a single instance in which the application of the silicate of potash, or waterglass alone, has proved beneficial in effectually preserving the stone of any public building in this country.

I would further observe that my various inventions and improvements have been the result of observations made in the actual manufacture and use of the soluble silicate, and that this material is now and has long been largely used in this country for the purposes already described, as also in several other important branches of manufacture. It is not my desire to detract from the value of the results obtained by Dr. Fuchs and Professor Kuhlmann's indefatigable and persevering investigations, which unquestionably have conferred great and lasting benefits upon the community at large; but having (as I think I have satisfactorily shown) devoted so large a portion of my life, and embarked a considerable outlay of money in conducting similar experiments, and bringing the same to a successful and practical application in this country, to the future development of which, and to the just recognition of my claims by the public, I naturally look for a return; I feel it due to myself and the interests of my family that my position shall be clearly understood, and with this view I appeal to the Society of Arts, so that, whilst extending through their journal the knowledge of the valuable researches and discoveries of men of science in other countries, they may not unconsciously commit an act of injustice towards the inventors of our own land.

[Copies of reports from Professors Henry, Ansted, and Mr. Robt. Hunt are appended, testifying to the value of the invention.]

ON THE FORM AND COST OF BREAKWATERS APPLICABLE TO HARBOURS OF REFUGE.*

By J. MURRAY, M. Inst. C.E.

(With an Engraving.)

IN reference to the form and cost of breakwaters applicable to harbours of refuge, Mr. Murray said, that a pier or mole, connected with the land and projected into the sea, was the simplest method of obtaining the requisite area for a harbour of refuge, but sometimes two moles were necessary. Their direction should conform as much as possible with the littoral currents, or sets of the tide, to prevent deposit. The entrance should afford easy ingress and egress in all winds, in a depth sufficient to enable vessels to enter, when fully laden, at dead low-water. In many cases an isolated breakwater was preferable, as there was less likelihood of the harbour silting up; and sometimes it might be so placed as to give the advantage of two entrances, open to different points of the compass. The sheltered area should be ample, under the contour of 3 fathoms at low-water, for a number of vessels to swing when dropping anchor; and a part of the shore should be appropriated for the beaching of vessels

* This paper was read at the Institution of Civil Engineers at the commencement of the present year: an abstract of it was given in this *Journal*, ante page 92. The paper *in extenso*, and Mr. Murray's subsequent remarks at the Institution which are appended, we have extracted from the Proceedings of the Institution, vol. xviii.

Digitized by Google

taking refuge in a disabled state. There should also be an inner pier or basin, having slipways, graving docks, and other conveniences, for the use of the shipping which might frequent the port. A harbour of refuge so placed did not require the inclosed water area to be as still as in a wet dock, where vessels loaded and discharged their cargoes alongside of quays. A little undulation of the water in the outer harbour was of no great consequence; and the projecting moles, or piers, would fully answer their purpose if the great force of the waves were broken, and they were thus prevented from doing injury to the vessels at anchor inside. The great sandbank of the Smethwick, those of Yarmouth and the Goodwins, arrested the ground-swell, and made the water area under their lee admirable harbours of refuge. Their utility only ceased when the tide rose to such a height, or the wind altered to such a direction, as to render the anchorage no longer a place of safety. If the moles were connected with the land their construction was more easily executed than in the case of an isolated breakwater, to which access could only be given to craft while the sea remained smooth. In consequence of the delay which an agitated sea often occasioned, it was well worthy of consideration, whether a temporary timber staging, or chains of suspension supported on temporary timber platforms, or some other appliances, could not be used to give access at all times to the works. Supposing this to be possible, there was then a connection with the land, by which the waggons used for the conveyance of the materials of construction might be brought to the spot required.

As to the work under low-water, it was generally admitted that rubble stone, used as "pierre perdue," remained stationary until it attained a height of 12 or 15 feet under low-water; and that the slopes of the deposited mass assumed an angle of 45°, or an inclination of 1 to 1. There could be little doubt of this being the cheapest method of bring up the works around the coast to 12 feet under low-water. But to make this important point evident, he had assumed a simple form for the transverse section of the mole, brought up from the bottom in a depth of 6 fathoms, with a spring-tide rise of 16 feet (Plate XXIV., figs. 1 and 2). The coping was taken at 10 ft. above high-water, without any parapet. The thickness of the outer wall at the top was 7 feet, and that of the inner wall 6 feet; the batter of the former was 3 inches, and that of the latter 1½ inch to a foot. In the calculations the following prices were assumed:—

	s.	d.	
Rubble stone deposited, after deducting for the interstices from ⅓th to ⅕th of the sectional area	3	6	per cubic yard.
When selected into different masses	4	6	,,
Freestone, set above low-water, including mortar, &c. &c.	1	6	per cubic foot.
Diving-bell work to ditto	1	0	,,
Use and waste of staging, according to the weights carried over it	from £6 to £10		per lineal yard.

Of course these prices would vary in different localities, and the calculations would be affected accordingly; but they were sufficiently accurate for the present inquiry.

The cost of bringing up the work to the depth of 12 feet under low-water, by means of the diving-bell, &c., would amount to per lineal yard,

	£	s.	d.	
2236 cubic feet of freestone, set with the diving-bell ... ... at 2s. 6d.	285	15	0	
57⅔ cubic yards of rubble filling (⅓th being deducted for interstices) ... at 3s. 6d.	10	1	5	
				£295 16 5

The cost of a simple deposit of rubble stone of the requisite width to receive the superstructure, would amount to per lineal yard,

209⅓ cubic yards of rubble filling (⅓th being deducted for interstices) ... ... at 3s. 6d.				£36 13 5

These sums were exclusive of staging in both cases.

It thus appeared that £296 was the cost, per lineal yard, of the work up to 12 feet under low-water, with an upright mole, against £37 with a rubble deposit; while the time which must be bestowed in the construction of the former would be far greater than in the latter. The cost of the upright mole would also be considerably augmented if the facing of the walls was of granite; and the interior filled with level courses of concrete blocks, as now practised at Dover. There were, therefore, good grounds for discarding the upright wall from the bottom, in favour of a simple rubble deposit.

The next question was the kind of superstructure to be placed upon it. The form might be varied in many different ways, but none was simpler than the profile delineated in Fig. 1. It was estimated that the cost of the superstructure, with connecting walls from low-water upwards 6 feet thick, and at central intervals of 20 yards, would then amount to

	£	s.	d.	£	s.	d.
Rubble deposit to 12 feet under low-water—Brought forward				36	13	5
900 cubic feet of freestone, set with the diving-bell ... ... at 2s. 6d.	112	10	0			
1394½ cubic feet of do. above low-water, at 1s. 6d.	104	11	4			
86⅔ cubic yards of rubble filling (⅓th being deducted for interstices) ... at 3s. 6d.	15	2	7			
162 cubic feet of freestone paving at 1s. 6d.	12	3	0			
In connecting walls:—						
194 4/10 cubic feet of freestone at 1s. 4d.	12	19	2½			
less 5⅔ cubic yds. rubble at 3s. 6d.	1	0	1½			
	11	19	1			
	256	6	0			
Use and waste of staging	6	0	0			
				262	6	0
Total per lineal yard				£298	19	5

Therefore, the total cost of the mole per lineal yard would be

1st. When constructed on a rubble stone deposit, brought up to 12 feet under low-water, and having a sectional area of 4149 superficial feet, £298 19s. 5d.

2nd. When the outer and inner walls were upright from the bottom, and having a sectional area of 3200 superficial feet, £558 2s. 5d.

These systems were however expensive, because much skilled labour was necessarily employed. For the purposes of a breakwater only this ought to be reduced to a minimum; dispensing, wherever it was possible, with masons and carpenters, and all diving-bell operations. Skilled labour was, no doubt, required at the pier-heads and entrances; but the expense, and above all the prolongation of time in getting the work done, indicated that such workmen ought not to be employed in the great bulk of the work.

Rubble stone breakwaters had been and were now being constructed, but they would have been executed at less expense if the sea-face had been solely defended by masses deposited to find their own slope, and of sufficient gravity to withstand the force of the waves. In the Plymouth breakwater the system first adopted was the employment of the largest stones that could be obtained from the quarries. At Portland and at Holyhead the large and small stones were used promiscuously, even the quarry rubbish being deposited for the purpose of filling up the interstices. The French engineers, on the contrary, considered the best system of employing rubble was not to mix the small with the large blocks. In one of their best constructed moles, that of La Joliette, at Marseilles, this method had been strictly adhered to (Figs. 3 and 4); and the new Mole D'Arène was to be executed in a similar manner. There was much to be said in favour of the system. The large blocks being only used where required, were not unnecessarily wasted in the heart of the work. Although there might exist considerable vacuities where the large blocks were exclusively employed, yet if perfect consolidation was attained by this method of construction, it was attended with a considerable saving of material. Mr. Murray could speak from his own experience as to the accuracy of the principle; for small pieces of stone mixed with large rubble, far from consolidating the work, very often had the effect of allowing the larger masses to be more readily displaced. He had often found stones weighing 5 tons and even 7 tons thrown out of place by the waves, in consequence of the small stones getting in between them, and keeping them in motion during every storm. If, however, heavy blocks only were employed, so as to remain stationary under the greatest action of the waves, nothing could be gained by the interstices being filled up.

At the assumed depth of 6 fathoms, where a breakwater was required to be constructed, the waves could have no effect on small stones until it reached 22 feet under low-water; hence the nucleus, or core, from the bottom to that height, might be wholly composed of third-class rubble, or from quarry rubbish to blocks of half a ton in weight (marked A, Fig. 2). This should be coated with second-class rubble (marked B) from half a ton to 2 tons in weight, which it was considered would remain stationary up to 12 feet under low-water. Then first-class rubble (marked

Digitized by Google

C) from 2 tons to 5 tons in weight, should be employed up to low-water, with a berm, or benching, on the sea-side, at a depth of 12 feet under it. In general the large class blocks from a quarry were from 5 tons to 9 tons in weight; but the latter were only occasional blocks, and they had not sufficient resistance to remain permanent much above the level of low-water, unless they were laid with a long slope. If, however, even larger masses could be obtained in the quarries, the lifting and transporting of them would be absolutely impracticable. The French engineers, in the construction of the new mole at Algiers (Fig. 5), found by experience that blocks of 10 metres cube, or about 22 tons, were requisite to withstand the shock of the waves. At Marseilles and at Cette (Fig. 6) the beton blocks weighed 25½ tons; but at Cassis (Fig. 7), in a more exposed situation, with very deep water outside, and a long fetch of sea, the outer face of the mole required blocks of 20 metres cube; for on trial, blocks of 10, and even of 15 metres cube were found insufficient. Artificial blocks of beton had also been used extensively at La Ciotat, and at Port Vendres, with perfect success (Figs. 8 and 9). It was therefore suggested for works of this description, that the upper part of a breakwater should be formed of beton blocks of 20 to 25 tons in weight, which it was considered would be of sufficient gravity to resist the force of the waves along the coast of Great Britain,—not however as a coating, but as a mass, terminating at the height of high-water; then for 10 feet or 12 feet above that level, two or three courses of heavy blocks should be laid, bonded and adjusted by manual labour.

As regarded the construction of these blocks, it had been found at Marseilles that when composed of hydraulic lime and sand, in the proportion of one part of mortar to two parts of broken stones, they cost, including all expenses, deposited in the work, the sum of £8 for each block, or 5½*d.* per cubic foot. At Algiers they cost something more; but Roman pozzuolano was employed in the manufacture, and labour in so warm a climate was not to be had so cheaply as in France. Mr. Murray had assumed 8*d.* per cubic foot as the price in this country, when deposited in the work; but he believed that the cost might be considerably reduced when made on a large scale, with the usual mechanical appliances, even with the use of Roman pozzuolano, for although labour cost more than in France, yet the stone and sand were at hand, and the blue lias lime was at no great distance.

Transverse sections, taken at different times during the progress of the works at Marseilles, proved that in every 3 cubic yards of space there were two parts solid and one void. The blocks of 10 metres cube, when deposited, assumed an angle under the water-line of 45°, and at this slope they were undisturbed by the heaviest gales. Mr. Murray had adopted for the proposed section of the breakwater a slope of 2 to 1 for the sea-side, and 1 to 1 for the inner slope.

Lastly, as to the cost. The estimate per lineal yard would stand thus:—

145⅞ cubic yards of 3rd class rubble, A (⅛th being deducted for interstices)					
121⅞ „ 2nd „ B (¼th „ „					
98⅝ „ 1st „ C (¼th „ „					
	£	*s.*	*d.*		
365⅝ „ ... ... at 4*s.* 6*d.*	82	3	6		
2568 cubic feet of artificial blocks of beton, or concrete, D (⅓rd being deducted for interstices) ... ... at 8*d.*	80	12	0		
750 ditto, ditto, E, at 9*d.*	28	2	6		
	190	18	0		
Use and waste of staging c	10	0	0		
				£200	18 0

This sum contrasted favourably with the estimated cost (£300 per lineal yard) of the mole founded on a rubble deposit, the saving on a mile of breakwater amounting to £176,000. But if the comparison was made with an upright wall of stone from the bottom, the difference would amount to £630,000 per mile, a sum almost sufficient to construct an ordinary harbour of refuge.

In the course of subsequent remarks upon his paper, Mr. Murray said, the cost of the mole of La Joliette, at Marseilles (Figs. 3 and 4), including the commercial quay, was according to the details given by M. Montet, the engineer, only about £260 per lineal yard. The quay was 60 feet in width, formed on the rubble deposit, and was well paved on a bed of concrete. The inner quay wall was built on beton, sunk in caissons, which rested on the berm or benching of the rubble deposit. As this portion of the structure formed no part of a breakwater such as they were now discussing, the cost of it, and of the adjacent quay should, he considered, be deducted, to arrive at the actual cost of the breakwater. He had gone into the question, and found that the rubble deposit, including the external coating of the large blocks of beton, amounted to about £154 per lineal yard. To this must be added the parapet, with its ashlar stone dressings, making, according to the following statement, the cost of the structure about £215 per lineal yard:

	£	*s.*	*d.*
285¾ cubic yards of rubble deposit from the small pieces to the larger masses of 8 tons in weight 6*s.* 3½*d.* per yard	89	19	9
8 blocks of béton of 25½ tons each ... ... at £8 each	64	0	0
	153	17	9
41 cubic yards of platform and parapet, with ashlar stone dressings ... ... at £1 10*s.* per yard	61	10	0
	215	7	9
Additional cost of making the inner side effective as a commercial quay	44	0	0
Total per lineal yard	£259	7	9

Fig. 3 is a transverse section of the Mole of Joliette; and Fig. 4 is a diagram showing the method of construction. The nucleus or core, marked A, was composed of a mass of small stones deposited as pierre perdue. It was afterwards coated with larger stones, marked B, weighing from 11 cwt. to 1¼ ton; and above that with other layers of stones, marked C and D, the former from 1¼ to 3½ tons, the latter from 3½ to nearly 8 tons. The hearting, B^1 and B^2, was composed entirely of small stones. The outer face was covered with artificial blocks of beton, which, when deposited in the sea at Marseilles, took an angle under the water-line of 45 degrees; and at this slope of 1 to 1 they were undisturbed by the heaviest gales. Above the water-line they were laid at a slope of 2½ to 1. The blocks were composed of hydraulic lime and sand, in the proportion of one part of mortar to two parts of stone broken into fragments, each capable of being passed through a ring 2 inches in diameter. They cost in masses of 10 cubic metres, including all expenses, when deposited in the work, 20 francs or 16 shillings per cubic metre. Such a block contained 353 cubic feet, or about 13 cubic yards. The engineers at Marseilles reckoned that a cubic metre of beton weighed 2600 kilogrammes; the weight therefore of each block was 25½ tons, and it cost, with all expenses in depositing it in the work, the sum of £8, or about 5½*d.* per cubic foot.

He would next direct attention to the Mole of Algiers, of which a transverse section was given in Fig. 5. After the French had taken possession of that port they first repaired the old jetty and mole, and then commenced the new mole, which was executed in a depth of water from 6 to 10½ fathoms, wholly with artificial blocks of beton of 10 cubic metres or about 22 tons each, prepared on the land and allowed to indurate before being conveyed by railways to the mole, and being launched into the sea as pierre perdue. M. Poirel, the engineer appointed to conduct the works at Algiers, gave an account of his operations in a work published in 1841;* in which were included details of the method of constructing the blocks, and of transporting them from the workyard to the place of deposit. Various profiles of the new mole were also given, and M. Poirel observed, that "although they differed somewhat from each other, yet they gave generally for the slopes at which the artificial blocks arranged themselves, a rate of 1 base to 1 perpendicular (45°) for the exterior, and of ½ base to 1 perpendicular (57°) for the interior side." M. Poirel further added, "that it appears, on a comparison of the cubic contents of the mole as given by these profiles, with the account kept of the quantities contained in the blocks immersed, that the interstices are very nearly one-third of the solids; or, which is the same thing, that the voids are equal to one-fourth of the whole mass." In prolonging the mole, since 1847, the French had adopted a cheaper system, by forming the mass from the bottom with blocks of natural stone, which were brought up till the uniform depth of 33 feet under water was attained, at slopes of 1 to 1. The upper part of the seaward side had been executed entirely with artificial blocks of beton. The mole at the water-line had been made 46 feet in breadth. The blocks took an average slope outside of 1¼ to 1. The expense of the work had amounted to 10,000 francs per running metre, or £366 per lineal yard; conse-

* *Vide* 'Mémoire sur les travaux à la mer, comprenant l'histoire des ouvrages exécutés au port d'Alger, &c.' Par M. Poirel. 2 vols. 4to. Plates. Paris, 1841.

Digitized by Google

quently the system adopted at Algiers had been more costly than the works at Marseilles.

On a coast with a rise of tide the works above low water could not have a slope of less than 2 to 1, and that would increase the expense if the same system were to be pursued; but it would not be requisite to deposit such a mass of artificial blocks, because a coating on the seaward side of about 20 feet in thickness would give sufficient stability to the structure, while the inner and less exposed side might be constructed with blocks of natural stone.

The French engineers considered the best system of employing rubble or pierre perdue, was not to mix the small with the large blocks. They therefore took care to select them into different classes, and employed the small pieces only in the heart of the work, increasing them in size according to their exposure to the action of the sea. When sufficiently large masses could not be obtained from the quarries, the artificial blocks were employed of such gravity as to remain stationary under the heaviest storms. The French engineers asserted that the selection of the stones for the different portions of the work was of great importance, and to that cause was attributed the construction of these works at a cheaper rate than was practicable under a different system in this country.

Another point alluded to in the course of the discussion was as to the disintegration of the blocks. Since M. Vicat published his work on mortars,* a variety of new limes had been tried in the public works in France, which had succeeded very well in fresh water constructions, but when applied to works in the sea they had failed. M. Feburier was deputed by the authorities of the Ponts et Chaussees to make experiments on the mortars employed at St. Malo, and to institute inquiries as to what had been done there. He found that too great economy had been used in the composition of the mortar, by the introduction of a fifth part of rich lime with the hydraulic lime, and that the result was a failure. After an inquiry extending over several years, M. Feburier arrived at the following conclusions:

1. That all the mortars experimented on with rich limes, sand, and pozzuolano, after drying in the air and being immersed in salt water, were destroyed. 2. That mortars formed with rich lime and Roman pozzuolano, and immersed in salt water, did not resist immediate action, whatever might be the proportion employed. 3. That mortars formed with hydraulic lime and sand acquired cohesion slowly; where more rapid setting was required a mixture of pozzuolano with the sand was necessary. And finally, that only eminently hydraulic limes ought to be employed in the composition of mortars exposed to the action of the sea.

From the commencement of the works at Algiers to the early part of 1852, the mortars employed were composed of rich lime, slaked in the ordinary method, with equal volumes of sand and Roman pozzuolano. Since January 1852 hydraulic lime had been exclusively used. The stone was brought from the Rhone, being the same as that employed for several years at the port of Joliette, at Marseilles. Observations were made on the artificial blocks at Algiers, by M. Ravier, which were published in the 'Annales des Ponts et Chaussees' for 1854. There was no apparatus for inspecting the works under water; as far as the blocks however could be examined during calm weather and clear water, the surfaces exhibited numerous incrustations. In feeling with a pointed rod of iron, no penetration could be made on the original surface of the beton, not even in places where the blocks had been broken in launching. M. Ravier broke off pieces of the blocks under water, both on the inner and outer sides, in different places in the length of the mole. On re-immersing the fragments made with rich lime, sand and pozzuolano, in salt water, they were found to be attacked in a few days on the newly exposed surfaces, and became rapidly decomposed, while the primitive surfaces were unaltered. The fragments immersed in fresh water remained without exception perfect. In June 1851, fragments of the blocks, rounded by attrition, were dredged from the port, near the intersection of the new with the old mole. They were placed in buckets, the one filled with salt the other with fresh water. The crust formed on the surfaces presented the same appearance as the portions detached from the slope of the mole. The position which they occupied afforded presumptive evidence that they had been manufactured twelve or fifteen years previously. The parts of the blocks alternately wetted and left uncovered, by the variation in the level of the sea, were subject to some alterations, but without any marked diminution of their volume. The alterations in the blocks placed above the water-line, although occasionally wetted by the waves and subjected to their action, were not important. Some of the surfaces were stripped of the mortar, leaving the small stones exposed, but others were as perfect as when they were made. Observations made on the blocks on the outside of the mole, where hydraulic lime had been exclusively used, indicated the most perfect state of preservation. It had been asserted that the waters of the Mediterranean exercised a different influence to that of sea-water generally; and that what might succeed in that inland sea would not answer in other places. In 1802-3, when Napoleon was annoyed by the English fleet blockading Rochefort, he ordered the construction of a large fort on the sandbank Boyard, at the distance of about two miles from the coast of Oleron, in the Bay of Biscay. The materials employed were small rubble stones, deposited to take their own slope. Storms arose and levelled the mass, and the only way of getting it to stand was by placing on the slopes, under low water and above it, artificial blocks 33 tons in weight, which were conveyed from the shore between pontoons, and sunk on the slopes. Although not laid in regular courses, yet their weight caused them to remain stationary; and when the slopes were so protected, the fort was erected in perfect safety.

Mr. Murray also exhibited a transverse section of the digue or breakwater at Cherbourg (Fig. 10), which was in itself an extraordinary structure. He introduced it to the attention of the Institution, to show the rapidity with which works under water were constructed with a simple deposit of rubble stone, in place of bringing up nearly perpendicular walls from the bottom. The first cone of that work was sunk in 1784, and the last in 1788. The extreme distance between them was 2 miles 3 furlongs, and in seven years the eighteen cones were connected in the whole of that length with a deposit of rubble stone. The rapidity with which that was done was very striking, it being an isolated structure, and carried out in an exposed bay. According to M. de Cessart, 5,300,000 tons of stone were deposited at a cost of £902,434. But with the extra pay to the troops and seamen, as stated in a report to the National Assembly, it was calculated to amount to £1,250,000, or about £300 per lineal yard. After standing till 1826, or thirty-eight years after the sinking of the last cone, small spots only were visible above the surface of the sea at low water of spring tides; but on the whole length the average height was about 4 feet under low water. Various additions were made to the digue up to 1832, when the cost was estimated at £413 per lineal yard. The new constructions, including the forts and central battery, brought up the whole expense to about £658 per lineal yard.

It had been stated that the works at Dover, even although connected with the land, had cost £880 per lineal yard on the average of the first contract; and during the existing contract, in a depth of water of 7½ fathoms, the cost was as much as £1245 per lineal yard. This formed a striking contrast with the expense of the isolated works at Cherbourg, including its expensive forts and batteries.

RESTORATION OF HEREFORD CATHEDRAL.

THE alterations and restoration of Hereford Cathedral, under the superintendence of Mr. G. G. Scott, are progressing satisfactorily. In the choir the arcading and parapet of the upper portion have been rebuilt, and the massive timber roof, which had become quite decayed, has been reconstructed and re-covered with lead sheeting. The restorations in the north transept are nearly completed. New geometrical tracery has been inserted in the three triangular windows of the clerestory, and the mouldings and corbels have been restored. The tracery is completed in the three circular windows of the library, which are restored in accordance with the originals, as proved from the fragments which have been preserved. The windows will shortly be glazed. The north-east buttress on the north side of the transept is being taken down, to be replaced by one similar to those on the west side of the transept, and new stone is being inserted on the north gable wherever unsoundness is detected. An octagonal spire, about 30 feet in height, will soon be completed on the north-west corner. The top will be surmounted by a finial of

* *Vide* 'Recherches expérimentales sur les chaux des construction, les bétons et les mortiers ordinaires.' Par L. J. Vicat. 4to. Plates. Paris, 1818. Translated, with the addition of explanatory notes, by Captain J. T. Smith, M.E. 8vo. Plates. London, 1837.

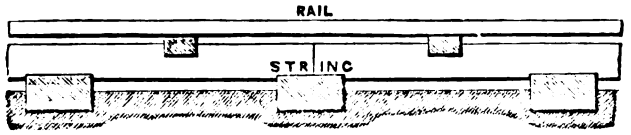
Digitized by Google

bold design, 3 feet in height, and the same in diameter. On the western side of the transept the buttresses and parapet are completed, and the process of finishing off will proceed without delay, so that the scaffolding can be removed and the windows glazed. The decoration of the ceiling of the north transept is completed. The patterns are varied, so as to avoid the monotony in the nave of which some people complain. Gilding has been freely used, and in the selection of colours the object has been as nearly as possible to reproduce the effect obtained when the transept was originally built, some 500 or 600 years ago. A great deal of stone carving has been completed, and among the portions of the work nearly 100 capitals have been prepared with the ornamental arcade, which will be restored on each side of the Lady Chapel. A new roof has been prepared for the dormitory at the College School, and the general alterations here have given to the school a much more collegiate character than it has hitherto borne.

SUGGESTIONS RESPECTING THE SUPERSTRUCTURE OF RAILROADS.*

By J. C. TRAUTWINE, Philadelphia.

I WOULD suggest to superintendents of railroads now in operation, the trial of a few rods in length of superstructure with string-pieces, and two sets of cross ties, as shown by the following sketch. The bottom of the string-piece is supposed



to be elevated about an inch above the ballast. It appears to me, that the elasticity insured to the rail *throughout its entire length* by this arrangement will be found to diminish to a very great extent the destructive *pounding* action which the engines exert upon the rails of all the superstructures now in use. Experience would soon point out the proper dimensions and distances apart of the timbers to be employed for engines of any given weight, in order to insure the requisite degree of elasticity, which evidently admits of being varied to any extent which may be found desirable. The increased quantity of timber involved in this proposed plan is a manifest objection to it; but experience only can indicate whether the attendant advantages which it possesses may not more than counterbalance this objection, together with any others to which it may be liable. Beside the greater presumed durability of the rail, *from the fact that no portion of it rests on a rigid support*, we should secure a much more efficient rail-joint; inasmuch as the joints would rest *upon* the upper cross ties, instead of *between* the ties, as is the present preferred practice; thus combining increased strength of joint with greater uniformity of elasticity. We also should elevate the rail more beyond the influence of snow. Moreover, should this expedient enable us to obtain that certain (uncertain?) amount of elasticity of rail which all engineers concede to be so important a desideratum, it will doubtless lead to the adoption of more efficient supports for the lower cross ties themselves,—supports which may extend below the influence of rain and frost; and thus effect a very important reduction of expense for rectification of the track, besides dispensing with the use of ballast.

The great objection to the employment of such supports hitherto, has been the increased *rigidity of track* attendant on them, and by which the destruction of the rail is greatly accelerated. But if we can devise a means of modifying or entirely annulling this rigidity *in the rail*, by a process *entirely independent of the foundation on which the rail rests*, then this objection vanishes, and the way seems to open for arriving at a much more perfect superstructure than has hitherto been used.

I hope that the subject may be regarded by some of our intelligent superintendents as being of sufficient interest to induce them to make a trial of it, if only for a few lengths of rail; and to communicate the result through your valuable journal.

* From the Journal of the Franklin Institute.

REPORT OF THE COMMISSIONERS OF PATENTS.

THE following is the report of the Commissioners of Patents for Inventions for 1858, which has just been printed by order of the House of Commons:

"The Commissioners of Patents appointed under the Patent Law Amendment Act, 1852 (15 & 16 Vict. c. 83), in compliance with the terms of the third section of that act, make the following report of their proceedings under and in pursuance of the same for the year 1858, in continuance of their report of proceedings for 1857.

The number of applications for provisional protection recorded within the year 1858 was 3007; the number of patents passed thereon was 1954; the number of specifications filed in pursuance thereof, 1880; number of applications lapsed or forfeited, the applicants having neglected to proceed for their patents within the six months of provisional protection was 1047.

The act 16 Vict. c. 5, enacts that all letters patent for inventions to be granted under the provisions of the Patent Law Amendment Act, 1852, shall be made subject to the condition that the same shall be void at the expiration of three years and seven years respectively from the date thereof, unless there be paid, before the expiration of the said three years and seven years respectively, the stamp duties in the schedule thereunto annexed, viz., £50 at the expiration of the third year, and £100 at the expiration of the seventh year.

Two thousand and forty-four patents bear date between the 1st July 1855 and the 30th June 1856; the additional stamp duty of £50 has been paid on 568 of that number; and 1476 have become void by reason of nonpayment.

All the provisional, complete, and final specifications filed in the office upon the patents granted under the act have been printed and published in continuation, with lithographic outline copies of the drawings accompanying the same, and within three weeks of the respective dates of filing, according to the provisions of the act 16 and 17 Vict. c. 115. The provisional specifications filed in the office, and lapsed and forfeited, have also been printed and published in continuation.

Printed certified copies of the specifications filed in the office, as also certified copies of patents, and of the record book of assignments of patents and licences, with copies of such assignments and licences, have been sent, in continuation, to the office of the Director of Chancery in Edinburgh, and the Enrolment Office of the Court of Chancery in Dublin, pursuant to the act of 1852 and the act of 16 and 17 Vict. c. 115.

The work of printing the specifications of patents under the old law, 12,977 in number, and dating from 1711 to 1852, having been completed, the Commissioners of Patents have directed short abstracts or abridgments of specifications, grouped under the different heads of invention, to be prepared and published: for example, abridgments of the specifications of patents relating to the propulsion of vessels, commencing in the year 1618 and ending 1857, comprising nearly 1000 inventions, have been published in three parts, making one small volume.

Abridgments relating to the following subjects of invention have also been published:—drain tiles and pipes; manufacture of iron and steel, three parts; manures; sewing and embroidering; preservation of food; aids to locomotion; steam culture. Other series are in the press, and it is intended to publish at the rate of six or eight series in each year, completing the work in eight or ten years. These abridgments are sold at prices a little above the cost of printing and paper.

The following report of the Commissioners of Patents on the subject of the building of a Patent Office and a Public Library has been transmitted to Her Majesty's Treasury:

To the Lords Commissioners of Her Majesty's Treasury.

The Right Honourable Frederic Lord Chelmsford, Lord High Chancellor of Great Britain, the Right Honourable Sir John Romilly, Master of the Rolls, Sir FitzRoy Kelly, Her Majesty's Attorney General, and Sir Hugh M'Calmont Cairns, Her Majesty's Solicitor General, being four of the Commissioners of Patents for Invention under the said Act, report as follows:

The 4th section of the said Act enacts, that 'it shall be lawful for the Commissioners of Her Majesty's Treasury to provide and appoint from time to time proper places or buildings for an office or offices for the purposes of the said Act.'

In pursuance of the requisition of the Lords Commissioners of Her Majesty's Treasury, dated in 1853, the Commissioners of Her Majesty's Board of Works provided certain offices for the Commissioners of Patents,

Digitized by Google

being the ground-floor rooms of the Masters' Offices in Southampton-buildings, Chancery-lane, theretofore occupied by Masters in Chancery, abolished under the Act 15 and 16 Vict, c. 80; and an annual rent of £490 is now paid out of the Fee Fund of the Patent Office to the Suitors' Fund of the Court of Chancery for the hire of the same. This arrangement was not considered to be permanent; no lease has been granted, and as these offices are now required for the occupation of the registrars and other officers of the Court of Chancery, due notice has been given to the Commissioners of Patents, requiring them to give up possession so soon as other suitable offices can be procured. These offices were in 1853 sufficient in number and accommodation for the ordinary business of the office.

In the year 1855 the Commissioners of Patents established a free public library within their office, containing works of science in all languages, the publications of the Commissioners, and the works upon patented and other inventions published in the British colonies and in foreign countries. This library has greatly increased and continues to increase, partly by purchases, but in a great measure by gifts and loans of valuable and useful books. It was resorted to at the first opening by inventors, engineers, and mechanics, as well as by barristers, solicitors, and agents engaged in patent business; it has become a collection of great interest and importance, and the number of readers has gradually so much increased, that at this time convenient standing room cannot be found in the two small rooms within the office which can be appropriated to the library. It is the only library within the United Kingdom in which the public have access not only to the records of the patents and inventions of this country, but also to official and other documents relating to inventions in foreign countries, and this without payment of any fee. A largely increased accommodation is urgently required. No suitable building can be found in the immediate neighbourhood of Southampton-buildings, either to be rented or for purchase.

The new offices to be provided must be fire-proof, for the preservation of the original specifications and other records of the office; the offices now occupied are fire-proof throughout.

The Commissioners of Patents are in possession of a collection of very valuable and interesting models of patented machines and implements, as also of portraits of inventors, many of them gifts, and others lent by the owners for exhibition. They are now exhibited daily, and gratuitously, in a portion of the Museum at Kensington assigned to the Commissioners of Patents for that purpose by the Lords of the Committee of Privy Council for Trade. A museum of this nature necessarily increases, and the number of models now exhibited may be considered as forming only the foundation of a great national museum.

The great work of printing the old specifications of patents, with the drawings attached thereto, enrolled in Chancery under the old law, dating from 1623 to 1852, and 12,977 in number, was commenced in September 1853, and fully completed in July last (1858). All have been fully indexed in series and subjects, and the indexes printed and published. These prints of specifications form about 900 volumes (450 imperial octavo volumes of drawings, and the like number of imperial octavo volumes of letterpress). The indexes form seven imperial octavo volumes. The cost of these valuable works has necessarily been great, amounting to £92,000. Notwithstanding this great outlay, the balance sheet of income and expenditure for the year 1857, prepared for the annual report of the Commissioners, and laid before Parliament, shows a surplus income from the commencement of the act, 1st October 1852, to the end of 1857, of £6000.

The balance sheet of income and expenditure for the year 1858, prepared and shortly to be laid before Parliament, shows a surplus on the year of £5900, thereby increasing the total surplus to £11,900.

The work of printing the old specifications being completed, as above stated, the expenditure on that head ceases altogether, and consequently, the surplus income of the current year (1859) is estimated at £21,600; adding this sum to the present available surplus of £11,900, and leaving a margin of £3500, £30,000 may be safely estimated as the sum available for building purposes at the end of the current year 1859.

The balance sheet of income and expenditure for the current year 1859 is estimated as follows:

Payments.	£
Fees to the law officers	8,700
Ditto their clerks	800
Salaries of officers and clerks	5,600
Compensations	4,600
Current and incidental expenses	7,500
Cost of stationery supplied to the Patent Office by her Majesty's Stationery Office	700
Cost of purchase of books for library, and binding	500
Rent of offices	500
Letterpress printing, lithographer's bills for drawings, and estimated cost of paper supplied to the printer and lithographer by her Majesty's Stationery Office	17,500
Expenses in respect of the Museum at South Kensington	3,000
Revenue stamp duties	16,300
Balance or estimated surplus income of the current year 1859	21,600
	£87,300

Receipts.	£
Stamp duties	86,000
Sale of printed specifications	1,300
	£87,300

The act of 1853 (16 Vict. c. 5) converted all the fees imposed by the act of 1852 into stamp duties, thereby passing the whole income to the consolidated fund. The expenditure in the office is estimated and voted annually by parliament. There is no appearance of diminution in the number of applications for patents, and they may be safely estimated to continue for future years at 3000 in each year. This number will produce £86,000 in stamp duties, and adding thereto £1300 for the average annual proceeds of sales of printed specifications, the future annual gross income may be taken at £87,300. The gross income is however liable to a deduction of £16,300 on account of revenue stamp duties, leaving the real available future income of the Patent Office at £70,000 per annum, or thereabouts.

The Patent Law Amendment Act, 1852 (15 & 16 Vict. c. 83) imposed certain revenue stamp duties upon patents. These duties have hitherto produced £15,300 per annum, and that sum has been charged against the office in the annual balance-sheet of income and expenditure. These duties are estimated in the balance-sheet above set forth for the current year 1859 to produce £16,300 or thereabouts.

The work of printing the old specifications being completed, as above stated, the yearly future cost of the current specifications, abstracts of specifications, journals, indexes, &c., in letterpress printing, lithographic printing, and paper, will not exceed £17,500 per annum, as contrasted with the average yearly expenditure on those three heads of £39,375 within the years 1856, 1857, and 1858.

The Commissioners of Patents are of opinion that it is not expedient, for the present at least, to propose to parliament a reduction of the scale of stamp duty fees imposed by the act of 1852. They are of opinion that the fees paid upon the passing of a patent are not too heavy: the large number of applications (3000 in each year) accounting for the large amount of income. Any material reduction in the amount of fees would undoubtedly tend to increase the number of useless and speculative patents, in many instances taken merely for advertising purposes. The fee stamp duties and the revenue stamp duties are as follows:

	Fee Stamp duties. £	Revenue. Stamp duties. £
Within the first six months from the petition for provisional protection to the filing of the specification	20	5
On the patent at the expiration of the third year	40	10
On the patent at the expiration of the seventh year	80	20

(The patent is granted for 14 years.)

There are 3000 petitions for provisional protection in each year, or thereabouts. Of this number, 1950 reach the patent, and 550 patents pay the £50 additional stamp duty required at the expiration of the third year; 1450 patents, or nearly three-fourths of the whole, thereby becoming void. Probably not more than 100 of the surviving 550 will pay the £100 additional stamp duty required at the end of the seventh year.

Considering the beneficial results of the additional payment of £50 in sifting useless patents, the Commissioners are of opinion that it is not expedient to reduce the amount, for the present at least, and so long as the surplus can be expended for the benefit of patentees and that portion of the community which is principally interested in and connected with the practical application to public purposes of discoveries and improvements in science and art.

They are of opinion that the surplus income, calculated as before stated to amount to £30,000 at the end of the current year 1859, and to increase in each succeeding year at the rate of £20,000 per annum, may be beneficially applied in the purchase of ground in a central situation, and in the erection thereon of a sufficiently spacious fire-proof building for the patent offices, and public free library attached thereto; and that the surplus fund may also be beneficially applied in the purchase of ground and the erection thereon of a permanent and spacious building for the Patent Office Museum, sufficient ground being taken for the extension of the building from time to time as may be required. This is the more necessary, inasmuch as models of the most interesting and valuable description lie scattered over the kingdom, in many instances constructed at a great expense, for legal and other purposes, for which the owners have no present use, and many of which occupy a space inconvenient to them. These models or many of them would, as the Commissioners confidently expect and believe, be presented or intrusted to them for exhibition in such museum, provided the public are allowed free access to it at all reasonable times.

The Patent Office is the place of constant daily and hourly resort of patentees, agents, and all others concerned in obtaining patents, and in ascertaining what discoveries and improvements have already been made. It should be conveniently placed with reference to the courts of law, the Government offices, and the offices of the Attorney and Solicitor General.

With respect, however, to the proposed new museum, the Commissioners of Patents are of opinion that the same reasons for a central position do not exist, and that it might be placed upon any spot easily accessible to the inhabitants of the metropolis, and that the place in which the models

Digitized by Google

are now exhibited would be an eligible position, sufficient ground being there purchased or assigned for the purpose. A large space will be required for the building in the first instance, and a larger extent must be provided for its future extension; and sufficient ground cannot be found in the centre of the town for a building of the extent required, unless at an enormous cost.

The Commissioners are anxious to establish a library in conjunction with the museum, showing the patents already granted by foreign governments, and those which from time to time are so granted; and from the facilities afforded by foreign governments the Commissioners have every reason to believe that this may be accomplished without difficulty.

These are the two objects which the Commissioners of Patents present to the consideration of the Lords Commissioners of Her Majesty's Treasury, and for which they are desirous to obtain their sanction:—1st. The erection of a museum for the preservation and exhibition of the models, as above mentioned. 2d. The erection of suitable offices. The latter of these objects ought properly to precede the former; but if the offices they at present hold in Southampton-buildings can be retained for the present, this object may be postponed till a convenient site can be obtained. For the accomplishment of the former object a very favourable opportunity at present occurs, as the Lords of the Privy Council constituting the Committee of Trade are (as the Commissioners are informed), willing to allot to them a portion of the land recently purchased at South Kensington, sufficient in extent both for the purpose of the erection of the building now required, and to provide for the future extension of the museum.

The Commissioners of Patents therefore request that the Lords Commissioners of Her Majesty's Treasury will be pleased to sanction the application of a sufficient portion of the surplus now derived from the fees paid on patents for the purpose of accomplishing the objects above mentioned, and that with this view their Lordships will be pleased to give the necessary directions to Her Majesty's Board of Works to obtain a proper site for the proposed new Patent Office and Library, to be selected with the approbation of the Commissioners of Patents and with the sanction of the Lords Commissioners of Her Majesty's Treasury, and also to prepare the necessary plans, elevations, and specifications for this purpose, also to be submitted to the Commissioners of Patents for their approval, and to make contracts for the building of the same when approved.

If their Lordships consent to these proposals, the Commissioners of Patents have to request that a sufficient sum for the purpose, so far as the same may be required for the year 1858-59, may be included in the estimate to be laid before Parliament in the present session for Patent Office expenses."

THE FREEZING POINT OF WATER IN CAPILLARY TUBES.*

By H. C. Sorby, F.R.S.

Upwards of two years ago, when making some experiments in order to ascertain the true nature of the liquid contained in the fluid-cavities in quartz, I thought that its freezing point was well worthy of being determined. Sir Humphrey Davy had long before shown (Philosophical Transactions, 1822, p. 367) that in many cases this fluid was water; and I had myself proved to my own satisfaction that water is given off from the cavities when the crystal containing them is heated so that the expansion of the fluid bursts them; but I was anxious to confirm this conclusion by some independent experiment, and to prove that it was water whilst still in the cavities. I therefore kept for a sufficiently long time a portion of rock-crystal, containing very excellent and distinct fluid-cavities about $\frac{1}{100}$th of an inch in diameter, in a mixture of snow and salt at a temperature far below the freezing-point of water; and then quickly placing it in a saturated solution of common salt previously reduced to a very low temperature, I was much surprised to find that the liquid in the fluid-cavities had not been frozen, but the enclosed bubbles still moved about like those in spirit-levels, when the fragment was turned round, just as they did at first. I again repeated this experiment along with Dr. Tyndall; and we both came to the conclusion that the fluid would not freeze at a temperature nearly 20° C. below the freezing point of water, or even lower than that of strong saline solutions, and therefore there was some doubt as to whether it really could be water or some saline solution. I, however, had such confidence in the value of other independent proofs, that I still adhered to the idea of its being water, and that the phenomenon must be owing to some peculiarity in the freezing of water in minute cavities. I afterwards learnt that Dr. Percy had made some experiments with water in capillary tubes, and had arrived at a similar conclusion. He has not, I believe, published an account of these, but kindly told me all the particulars. In his experiments the water apparently did not freeze at all: but when in such minute tubes it is difficult to ascertain for certain whether the water is frozen or not, if it be merely examined with an ordinary magnifying glass: and therefore, thinking there might still be some doubt about this, I resolved to carefully investigate the whole subject.

Of course we all know very well that the temperature at which water will freeze is not necessarily that at which it thaws. It has long been known that the temperature may be reduced very considerably below 0° C. if no ice be present and the water be kept tranquil, freezing however when agitated. If the water be in a glass tube about one-fourth of an inch in diameter, the temperature can easily be lowered to —5° C. (23° F.), even when the tube is shaken; and if kept quiet, the temperature may be reduced somewhat more. At —6°, however, it freezes at once, even when kept perfectly quiet. The same takes place in tubes $\frac{1}{40}$th of an inch in diameter; but when much less than that the result is very different

To ascertain beyond all doubt whether the water in very minute tubes was liquid or in a state of ice, I had recourse to the aid of the microscope and polarised light. In using this, some care is required. The analyser should be so arranged as to have a perfectly dark field; and the plane of the polarisation of the light should be either in the line of the length of the tube or at right angles to it; for if not, the light is depolarised by the curving sides of the tube. When all is properly arranged, and the focus adjusted to the centre of the tube, if it contain liquid water the whole field appears dark, and no white line is to be seen down the centre of the tube; whereas, if the water be frozen the double refraction of the ice depolarises the light, and the tube appears as if it contained a white substance, which vanishes as the ice thaws. In order to delay the thawing, the small tube should be examined when inside a larger vessel containing a strong solution of common salt.

The capillary tubes used in my experiments were prepared by drawing out, when melted, the tubes used for alcohol thermometers; and their internal diameters were ascertained by measuring them at the broken ends by means of the microscope-micrometer, because the bore appeared about $\frac{3}{2}$ of the actual diameter when seen at the side through the curved glass. I made experiments with those whose diameters varied down to nearly $\frac{1}{1000}$th of an inch; but when so small as that the depolarising action of the ice is so weak that it is impossible to be quite sure whether they contain water or ice. Those, however, from $\frac{1}{200}$th to $\frac{1}{300}$th of an inch in internal diameter are in every respect most satisfactory; for there is no difficulty whatever in deciding this point with polarised light in the manner just described. When water is contained in such tubes, we can readily reduce the temperature to below —15° C. without using any care to keep them quiet; and even when we shake them very violently, it will not freeze. The temperature may even be reduced to —16° C. (3° F.) without taking any precaution to keep it still; but at —17° C. the water freezes at once, even when kept perfectly quiet. It will thus be perceived that there is a difference of about 11° C. (20° F.) between the temperature at which water freezes in tubes of about $\frac{1}{4}$th of an inch in diameter and in those less than $\frac{1}{200}$th, which is so great a difference that there is no chance of its being an error of observation.

So far as I was able to ascertain, there was no very decided difference in the temperature in the case of tubes varying from $\frac{1}{200}$th to $\frac{1}{700}$th of an inch in diameter, nor in the case of tubes from $\frac{1}{4}$th to $\frac{1}{40}$th; but in a tube of about $\frac{1}{100}$th the water froze at about —13° C., but not at —11°, which is clearly a temperature intermediate between that required for those of $\frac{1}{40}$th and $\frac{1}{200}$th. It must not however be supposed that water will not freeze in minute tubes at a temperature very little lower than 0°. C., if the water be in contact with ice. When a tube of considerable diameter in one part is ever so fine in another, the contact of ice causes the water to freeze right down into the capillary part of the tube, at a temperature very little lower than 0° C.; and ice thaws as usual at 0° C. when in tubes in which water will not freeze until the temperature has been reduced to —16° C.

It therefore appears to be completely proved that water will not freeze in tubes of very small internal diameter, even when they are shaken, at a temperature very considerably lower than that at which it freezes at once in larger tubes, even when kept perfectly still; as though the actual size exerted a most decided influence in preventing the crystallisation of water, which freezing essentially is. In this respect water does not stand alone; for

* From the 'Philosophical Magazine.'

Digitized by Google

the same retarding action is exerted on the crystallisation of salts from solution. This is well seen in the case of bichromate of potash; for in some cases, when in a very minute state of division inside the fluid-cavities in other salts, a strong hot solution will not deposit any crystals on cooling, even after having been kept for upwards of a year, but remains as a deep yellow liquid, containing relatively far more of the bichromate in solution than can be retained when the liquid is in larger quantity. Small portions of lava have also often remained as an uncrystalline glass inside the minute cavities in the minerals of volcanic rocks, though it has entirely passed into a crystalline stone when in larger masses.

AN AMERICAN HOTEL.

The new Fifth-avenue Hotel in New York covers sixteen "lots" of ground, is seven stories high, and has an elevation, from the cellar to the roof, of 107 feet. The front, on Fifth-avenue and Broadway, is 202 feet; on Twenty-third-street, 215 feet; and on Twenty-fourth-street, 196 feet. The main entrance is on the Fifth-avenue. On the right of this is the grand stairway, opening from the hall, and on the left is the business office. In the rear of the main floor is situated the billiard and chess-rooms on the one side, and the gentlemen's exchange and reading-room on the other. There will also be attached to the house a Parisian restaurant, not only for the guests, but as a place where other gentlemen and ladies may dine with their families or friends, genteelly and economically.

On the second floor are the public and private parlours, opening into a corridor 613 feet long, running the entire length of the building. At the end of this corridor is the grand promenade, nearly 30 feet wide, uniting with the grand dining-hall at its western extremity, and presenting, with its double rows of columns, a magnificent *tout ensemble*. The grand dining-hall is 80 feet long, 60 feet wide, and 21 feet high, lighted with elegant chandeliers hung from a frescoed ceiling supported by Corinthian columns. Between the latter, on one side, are placed magnificent mirrors; while between the same, on the other, are placed beautiful French buffets.

The house contains 8 large public parlours, 120 private ditto, 4 dining and tea rooms, 420 chambers, and other rooms for servants, &c. Nearly all of the principal chambers have baths and water arrangements complete, there being fully 100 baths in all.

To facilitate communication between the several stories, there is provided a luxurious car, or ladies' carriage, which is capable of seating ten persons, and is caused to glide from the lowest floor to the uppermost story; this car is propelled by steam power, passes up a revolving spiral shaft near 100 feet in height, and is provided with a most efficient hydraulic device for ensuring the safety of persons within it, in case of the breaking of any of the hoisting tackle.

The whole building will be supplied with an independent gas apparatus, costing about 6000 dollars, by which the expense of illumination, as already proved in actual service, is reduced one-half in comparison with the city charges. The gasometer for the Fifth-avenue Hotel holds 63,000 cubic feet, and will supply 3000 burners. Iron tanks are used instead of the ordinary cisterns.

The plan of ventilation is very effectual, the heat of the furnaces being conducted into flues extending over the house, thereby creating a strong draught, and exhausting the atmospheric impurities of the various apartments.

The building is heated by steam, for which three boilers, each 22 feet in length and nearly 5 feet in diameter, are provided. From these the steam is conducted by pipes all over the building, the condensed steam being carried back to the boilers by a return flue. The boiler and gas-house occupy a distinct building wholly detached from the main structure.

Among other novel and curious kitchen apparatus are ten monster steam kettles, each weighing nearly 1000 lb., for boiling vegetables, &c. All the various machinery for cooking, washing, ironing, and other processes, is in a building specially constructed, and of sufficient capacity to supply the wants of 1000 guests.

The entire cost of this establishment will exceed one million dollars.—*New York Journal of Commerce.*

REVIEWS.

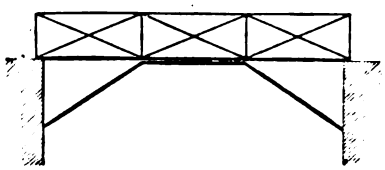
The Carpenter and Joiner's Assistant.—London: Blackie and Son.

The issue of six parts of this work since our last notice of the subject gives an opportunity of again drawing attention to the useful and strictly practical way in which it is conducted, as well as to the copious illustrations on steel and wood which serve to elucidate the text. The numbers before us embrace the general headings of roof, with a full explanation of the principles of framing, joints, and straps,—trussed girders or beams,—floors,—partitions,—timber houses,—bridges,—centres,—gates,—mouldings in general,—and joints. The engravings, which do not all range with the letterpress in its present form, comprise among others—timber steeples (American examples), joints, (scarfing, lengthening beams, &c.), French floors and floors constructed of short timbers,—centres,—Gothic mouldings,—doors,—timber houses,—timber bridges,—American ditto,—stairs, circular and otherwise,—handrails,—studies in sciagraphy,—and perspective diagrams; all rendered with great precision and clearness. The subjects of roofing, bridges, and stairs, are especially dwelt upon, and numerous executed examples of each are cited and described.

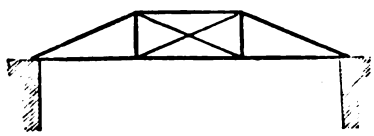
A lengthy section is devoted to explaining the various systems of *Bridge-building*, upon which a great amount of information has been amassed, and the several calculations upon which the axioms are based being given *in extenso*, the scientific reader will find this chapter a highly interesting and valuable one.

Five classes of bridges are specially enumerated, which may be resolved into the following elementary figures:—

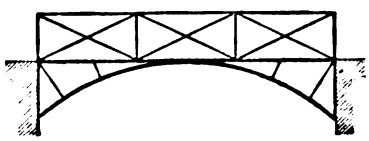
"1. Trusses which are below the roadway, and which depend for their stability on the abutments.



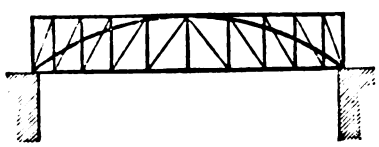
2. Trusses which are above the roadway, and have only vertical pressure.



3. Trusses below the roadway, composed of timber arches, and ties and braces, but dependent on the abutments for resistance to lateral thrust.



4. Trusses above or below the roadway, composed of timber arches, and ties and braces, and which have only vertical pressure.



5. Lattice trusses above the roadway."

Of the former class are described, a timber drawbridge on the Gotha, Sweden; and one erected over the Spey, at Laggan Kirk, by Telford, in which the material is employed most judiciously to obtain the greatest result by the smallest means; and the details, as in all the works of this eminent engineer, are worthy of careful study.

Of the second class is illustrated a bridge over the Don, at Inverury, on the Great North of Scotland Railway. It consists of ten bays, of which four span the ordinary bed of the river, and was commenced in 1853, and opened in September 1854.

"All the timber used in the structure is of the best Memel. The piles and braces of piers 12 inches by 12 scantling. The head-pieces of the

Digitized by Google

piers 12 inches by 9. The tie-beams of the trusses 12 inches by 9. The struts, straining-beams, and queen-posts of the trusses 12 inches by 12, and the diagonals 12 inches by 8.

All the wrought-iron work of the bolts and straps is of BB. crown Staffordshire iron. The toes of the pier timbers are shod with Staffordshire boiler-plate; and the caps over the queen-posts, the shoes under the tie-beams, and the strap bars at the springing of the trusses, are of ordinary grey cast-iron.

"The bed of the river consisted of large loose gravel and stones, lying on an under stratum of strong dark-coloured clay, into which the piles were driven several feet.

The water piers consist of seven piles, with longitudinal braces, diagonals, and cap-cills, arranged in such manner as to insure rigidity and strength. The distance between the extreme piles of each pier is 45 feet, this distance being considered necessary to resist the shocks given on the breaking up of frost in winter, when the river, swelling to a great height, hurls along with it enormous quantities of ice. Lumps of ice, weighing from 5 to 8 or 10 tons, have been seen shooting through this bridge with the velocity of seven miles an hour; and in severe winters sheets of ice half a mile in length frequently pass through.

The piers are all covered to a foot below the summer level of the water with 3-inch planks, spiked at the crossing of each timber. Filling-in pieces, 12 inches by 6, are introduced at the centre pile to receive this covering. Toe-pieces, 12 inches by 6, triangular in form, are faced on the outer piles; and these, and the ends of the covering, are further protected by sheets of boiler plate, 5 feet long, firmly bolted and spiked. Below the planking, the intervals between the piles are filled in with rough pitching of large rubble stones, and their exterior is surrounded with the same material.

All joinings of the timbers of the piers are secured by straps on each side 3 inches wide by ¾-inch thick, bolted together with ¾-inch diameter round bolts: where timbers cross each other, round bolts 1¼ inch diameter are used. The ends of the timbers are tenoned into mortises formed in adjoining beams. The diagonals of the piers are placed so as to form supports under the ends of the struts of the trusses.

Each truss consists of two parallel tie-beams, queen-posts, struts, straining-beam, and diagonals. The tie-beams are placed 9 inches apart, and the queen-posts and struts pass through between them, having shoulders 1½ inch deep on each side. The straining-beams, struts, queen-posts, and diagonals are all mortised and tenoned together, and fastened with straps, 3 inches by ¼, with ¾ bolts. A round bolt 1¾ inch diameter is passed through each queen-post and its cast-iron cap and shoe, and being firmly screwed up with nut and jam-nut, the whole truss is braced together, so as to give a slight camber to the tie-beam.

The struts of the adjoining trusses abut against each other, the abutment being about 8 inches deep. They are secured by straps 3 inches by ¾, passed round the ties and screwed at the ends, to receive the cross cast-iron bars. The straps are increased in size in the centre to receive bolts which pass through the ties and strut. The tie-beams are scarfed over the piers, and secured by bolts.

The roadway consists of transverse beams, laid 4 feet apart from centre to centre. The beams are 18 feet long, and 12 inches by 10 scantling: they are supported by the trusses, which are 14 feet apart, from centre to centre. Each beam is fastened by bolts, 1 inch diameter, to one of the tie-beams at each end; and the whole surface between the trusses is covered with 3-inch planking, on which the railway chairs are laid, and spiked through to the transverse beams.

The piles, the covering of the piers, and the roadway, are payed over with two coats of Archangel tar and pitch at a boiling heat; and the remainder of the timber work is painted three coats in white lead and oil.

All the timber is cleaned except the planking, which is rough from the saw. The iron work was painted first one coat in red lead, and then two coats in black lead and oil.

During the winter of 1853-54, the temporary bridge was carried away by the breaking up of the ice; and two of the permanent piles, which were not connected with the others, and therefore unsupported, were broken over: beyond this no casualty occurred, nor was any special difficulty incurred in the execution of the viaduct."

Of the third class is given the bridge over the Tyne, at Linton, on the North British Railway. This bridge was originally constructed entirely of freestone. Between the abutments, from which the struts spring, there were two stone arches, with a pier in the centre of the river; but, owing to the insufficiency of the foundation of this pier, it was swept away by a flood of unprecedented magnitude in September 1846, after the opening of the North British Railway: the abutments, however, remained uninjured. It became a matter of importance to repair this accident as soon as possible, to admit of the passage of trains; and with this view it was determined to erect, between the abutments of the arches which had fallen, the timber bridge shown on the drawings. This erection was put up very rapidly, owing to the simplicity of its construction; and it has been found to answer its purposes perfectly. The opening is 90 feet wide, and the bridge consists of a built or laminated chord, constructed of five planks each 12 inches by 3 in scantling. Immediately beneath these is a straining-piece 12 inches by 6, and 72 ft. long, with struts 12 inches by 9. Under this a series of eight transverse timbers serve to unite all the frames.

Plate LIV. illustrates "American bridges," and in particular the system referred to as class 4. In this mode of combining an arch with a trussed frame, the arches are connected with the tension posts, and the posts with the chords, by screw fastenings; and all is so arranged as to admit of changing the position of the arches relatively to the chords, without changing the position of the arches, and thus regulating or distributing the strain over the different parts of the bridge at pleasure.

"The following are the directions of Mr. Steele, the patentee of this mode of construction, to be attended to in the erection of one of his bridges, extracted from Haupt's 'Treatise on Bridges':—

The truss must first be erected, provided with suitable cast-iron skew-backs to receive the braces and tension-posts; and the several parts of the chords should be connected with cast-iron gibs. Wedging under the counter-braces must be avoided by extending the distance between the top skew-backs sufficiently to bring the tension-posts on the radii of the curve of camber of the bridge. The tension-posts must be about eight inches shorter than the distance between the chords; and in screwing up the truss care must be taken not to bring their ends in contact with the chords; but they must be equidistant, and about four inches from them. When the truss is thus finished, it must be thrown on its final bearings; and it is then ready to receive the arches, which should be constructed on the curve of a parabola, with the ordinates so calculated as to be measured along the central line of the tension-posts. They must be firmly fastened to the posts and bottom chords by means of strong screw-bolts and connecting plates, and should foot on the masonry some distance below the truss, which can be done with safety, as the attachment to the posts and chords will relieve the masonry of much of their horizontal thrust. When a bridge so constructed is put into use, it will be found, as the timber becomes seasoned, that the weight will be gradually thrown upon the arches, which will ultimately bear an undue portion of the load. To avoid this the camber must be restored and the posts moved up, so as again to divide the strain between the truss and the arches. This adjustment must take place once or twice in each year, until the timber becomes perfectly seasoned; after which, in a well-constructed bridge, but little attention will be required. Plates of iron should in all cases be introduced between the abutting surfaces of the top chords and arches; and all possible care taken to prevent two pieces of timber from coming in contact, by which decay is hastened: care should also be taken to obtain the curve of the parabola for the arches; as it is the curve of equilibrium, and of greatest strength, as has been shown by experiment.

Bridges constructed on this plan, will be found to possess an unusual amount of strength for the quantity of material contained in them; and, if well built and protected, great durability."

The construction and properties of one of these bridges are analysed with extreme accuracy, and the details are given at length, and since they afford a complete insight into the relations of such matters generally, we shall extract them in full.

"The bridge is in two spans, each 148 ft. 3 in. from skew-back to skew-back, or 154 ft. 6 in. from the middle of the pier to the end of the truss. The pier is 3 ft. 2 in. wide on the top, and 6 feet at the skew-backs.

The truss consists of three rows of top and bottom chords, and two sets of posts and braces. It is counter-braced by rods of inch iron between the braces. The panels increase in width from the end towards the middle of the span. The first are 9 ft. 1½ in. from centre to centre of posts, and the middle ones 12 ft. 1½ in.

The quantity of materials in this bridge is given by Mr. Haupt as follows:—

Timber for one Span.

3	wall-plates	...	... 8	by 16	18 feet long	B.M.	... 576
20	chords	...	... 6	„ 13	36 „	„	... 4680
10	„	...	... 8	„ 13	36 „	„	... 3120
10	„	...	.. 8	„ 10	36 „	„	... 2400
20	„	...	... 6	„ 10	36 „	„	... 3600
56	posts, yellow pine		... 9	„ 12	23 „	„	... 11592
4	king-posts	...	... 9	„ 16	23 „	„	.. 1104
15	floor-beams	...	... 8	„ 14	18 „	„	... 2520
14	„	...	... 7	„ 14	18 „	„	... 2058
56	lateral braces		... 4½	„ 7	8¾ „	„	... 1213
3	„	...	... 4½	„ 7	13 „	„	... 103
30	roof-braces	...	... 4	„ 5	17 „	„	... 850
56	check-braces	...	... 9	„ 20	3 „	„	... 2520
56	„	..	... 9	„ 23	5 „	„	... 2898
60	main-braces	...	... 6	„ 9	19 „	„	... 5130
15	tie-beams	...	... 8	„ 10	19 „	„	... 1900
8	purlins	...	... 4	„ 6	20 „	„	... 320
					Carried forward	...	... 46584

Digitized by Google

						Brought forward	...	...	... 46584
135 rafters	...	...	3	by	5	10½ feet long	B.M.	...	1772
15 roof-posts	...	...	4	,,	5	3 ,,	,,	...	75
30 knee-braces	...	...	5	,,	5	5 ,,	,,	...	312
16 track stringers		...	8	,,	10	20 ,,	,,	...	2133
3300 feet B.M. ¾ inch sheeting for roof								...	3300
56 arch-pieces	...	...	9	,,	11	25 ,,	,,	...	11550
7000 feet B.M. inch boards, for weather boarding, 20 feet long								...	7000
									72726

Weight per lineal foot, 1416 lb. No. of cubic feet per foot lineal, 40.

Counter-brace Rods for one Span.

4 rods for 1st panels, each	24	ft.	3	in.	long,	1	inch diam.	...	97·0 feet
4 ,, 2nd ,, ,,	24	,,	2	,,		1	,,	...	97·0 ,,
4 ,, 3rd ,, ,,	24	,,	8	,,		1	,,	...	98·7 ,,
4 ,, 4th ,, ,,	25	,,	0	,,		1	,,	...	100·0 ,,
4 ,, 5th ,, ,,	25	,,	2	,,		1	,,	...	100·7 ,,
4 ,, 6th ,, ,,	25	,,	8	,,		1	,,	...	102·7 ,,
4 ,, 7th or mid. pan.	26	,,	0	,,		1	,,	...	104·0 ,,
							Total lineal feet	...	... 700·1

Weight in pounds at 2·65 per foot = 1855 lb.

Arch Suspension Rods for one Span.

4 rods, each	6 ft.	8 in.	1⅜ inch diameter.
8 ,,	10 ,,		
8 ,,	13 ,,		
8 ,,	15 ft.	6 in.	
8 ,,	17 ,,	2 ,,	
8 ,,	18 ,,	2 ,,	

Total length 322 feet. Weight at $4\frac{24}{100}$ lb. per foot, 1590 lb.

Lateral Brace Rods for one Span.

15 rods, each 16 ft. 9 in. long, 1 inch diameter, 655 lb.

Small Bolts for one Span.

60 bolts, through arches, 47 inches long, 1 inch diam. ...	... 622 lb.
60 bolts, through chords and posts, 34 inches long, ¾ in. diam. ...	255 ,,
30 roof-bolts, 36 inches long, ¾ inch diam.	... 135 ,,
224 spikes for braces, ¾ lb. each	... 168 ,,

Mr. Haupt has given an analysis of the strains upon this bridge as follows: and it affords an example of his process of working out the problem of the stability of a timber bridge of this kind:—

Dimensions and Data for Calculation of Bridge at Sherman's Creek.

Span at skew-backs	148 ft. 3 in.
Whole length of truss for one span	154 ,,
Out to out of chords	20 ,,
Middle to middle of chords	19 ,,
Resisting cross-section of upper chords	400 sq. in.
Resisting cross-section of 6 lower chords, deductions for splice, check-brace, and bolt, and allowing for scarf-key	280 ,,
Versed sine of lower arch	20 feet
Cross-section of 8 arches	800 sq. in.
Span 148½, and rise 20, will give radius	... 172·25 feet
And 172·25, 152·25, and 74·125, express the proportion of the hypothenuse, perpendicular, and base of skew-back.	
Hypothenuse of skew-back covered by arches	18 inches
Perpendicular ,, ,, ,, ...	16 ,,
Base ,, ,, ,, ...	7·6 ,,
Distance from skew-back to bottom of arch	4½ ,,
,, ,, middle of skew-back to middle of chord ...	4 ft. 5 in.
Width from out to out of chords	16 ,, 2 ,,
,, between chords in the clear	11 ,,
Distance from centre to centre of floor-beams	5½ feet
Weight of one-half span complete (77 feet) ...	... 120,000 lb.
Distance of centre of gravity from point of support ...	37 feet
Weight of one-half span with load	... 275,000 lb.
Distance between shoulder of post	15½ feet

*Calculation of Truss without the Arches.**

Let x = distance of neutral axis from top chord.

$19-x$ = distance of ditto from bottom chord.

P = pressure per square inch on top chord.

$\frac{P}{x}(19-x)$ = strain per square inch on bottom chord.

$x = 8{\cdot}3$ = distance of neutral axis from top chord.

$19 - x = 10{\cdot}7$ = distance of neutral axis from bottom chord.

P = 1532 lb. = pressure per square inch on top chord.

$(1532 \div 8{\cdot}3) \times (19-8{\cdot}3) = 1975$ lb. = strain per sq. inch on bottom chord.

$$400\,Px = 280\,\frac{P}{x}(19-x)^2.$$

$$400P \times 8{\cdot}3 + 280P \times \frac{10{\cdot}7}{8{\cdot}3} \times 10{\cdot}7 = 275{,}000 \times 37.$$

* The reader will readily discover that Mr. Haupt, in general, uses the approximative round numbers in his calculations, for the sake of simplicity.

The bottom chords derive some assistance from the masonry; but as the roadway is on the bottom of the truss, little opportunity is given for wedging the lower chords; and for this reason the assistance to be derived from this service is not estimated.

Ties and Braces.

The weight upon the middle panel (12½ lineal feet) is 45,000 lb. To resist this there are four posts, the cross-section of each being 72 square inches, or the united cross-section 288, equivalent to 156·25 lb. per square inch.

The distance between the shoulders of the posts being 15½ feet, and the width of the middle panel, exclusive of posts, 11½ feet, the diagonal will be 19·3.

The strain upon the diagonal will be $45{,}000 \times \frac{19{\cdot}3}{15{\cdot}5} = 56{,}000$ lb, which divided by the cross-section of the four braces will make the pressure per square inch $\frac{56{,}000}{216} = 260$ lb.

The expression for the limit of the resistance to flexure, $w = 4 \times \frac{9000\,BD^3}{l^2}$, gives the present case $w = \frac{9000 \times 9 \times 6^3}{19{\cdot}3^2} = 46{,}000$ lb; or, for

The four braces	184,000 lb
The actual pressure	56,000
Difference in favour of stability	128,000

The strain upon the end ties, which sustain the weight of half the bridge, will be 275,000 lb, the cross-section being as before 288 square inches: the strain per square inch will thus be 955 lb.

The width of the end panel being 8½ feet, exclusive of posts, and the distance between the shoulders of the posts being as before 15½ feet, the diagonal will be 17·7 feet, and the pressure in the direction of the braces $\frac{275{,}000 \times 17{\cdot}7}{15{\cdot}5} = 314{,}000$ lb = 1451 lb per square inch.

The limit of the resistance to flexure for the four braces is expressed by $w = \frac{9000 \times 9 \times 6^3}{17{\cdot}7^2} \times 4 = 223{,}000$ lb.

As the pressure is 314,000 lb, it appears that with the assumed weight of a train of locomotives, or one ton per lineal foot besides the weight of the structure, the end braces would yield by lateral flexure in the direction of the plane of the truss, if not supported in the middle. If an intermediate support be used the resistance will be quadrupled, and will be amply sufficient.

It is also necessary to examine whether the braces, if supported in the middle in the direction of the plane of truss, could yield laterally in the direction of the perpendicular to this plane: the relative resistances in the two cases are as $6 \times 9^3 : 9 \times 6^3$, or as 9 : 4. The limit in this case would therefore be $\frac{223{,}000 \times 9}{4} = 502{,}000$ lb, which is more than the pressure (314,000 lb).

It appears therefore from this calculation that if the arches are omitted the end braces should be supported in the middle by diagonals in the opposite direction. As an additional security the depth should be increased to 9 inches. In the other panels they should diminish gradually to the middle of the span, where the original dimensions are sufficient.

Floor Beams.

The floor beams are 7 by 14 inches, width in clear between supports 11 feet, distances from centre to centre 5½ feet. The weight on the drivers of a locomotive, 18 tons, may be considered as distributed nearly equally over three floor beams, which will give 6 tons for each beam. $6 \times 3 \div 5{\cdot}5 = 3{\cdot}3$ tons = the equivalent weight in the middle of the beam.

$$R = \frac{18wl}{bd^2} = \frac{18 \times 6600 \times 11}{7 \times 14^2} = 952 \text{ lb} = \text{maximum strain per square inch.}$$

Lateral Braces.

The lateral braces are 4½ inches by 7, and 8 feet long. The prevalent winds are in a direction nearly parallel to the axes of the bridge, so that its exposure is not great. Assume as the basis of a calculation that the sides are closely boarded 20 feet high, and that the perpendicular force of wind may be 15 lb. per square foot: the whole pressure upon one span will be, say 45,000 lb. As there is lateral bracing both above and below, this pressure would be resisted by four lateral rods 1 inch diameter = 3·14 square inches, or 14,330 lb. per square inch.

The proportional strain upon the lateral braces would be $\frac{45{,}000 \times 8}{5}$ = 72,000, to resist which are four braces $4\frac{1}{2} \times 7 = 126$ square inches = 571 lb per square inch. The bearing surface at the joints does not much exceed one-half the area of the cross-section, consequently the actual pressure at the joints will be about 1000 lb. The limit of flexure of the four braces is expressed by $w = \frac{9000 \times 7 \times 4\frac{1}{2}^3}{8^2} \times 4 = 360{,}000$ pounds nearly. The maximum pressure is 72,000 lb. Difference in

Digitized by Google

favour of stability 288,000 lb. The lateral braces cannot yield either by crushing or bending, and are therefore amply sufficient.

Could the bridge if not loaded be blown away?—The weight of one span has been found to be 240,000 lb.

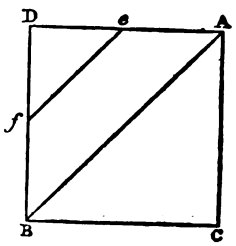
The resistance to sliding would be	120,000 lb	
The pressure of wind	45,000	
Difference in favour of stability ...	75,000 lb	

Could the bridge yield to the force of the wind by rotation around the outer edge of the chord?

The effect of the wind, 45,000 lb, acting with a leverage of 10 feet, would give for the disturbing forces	lb 450,000
The resistance = weight of bridge × half-width from out to out = 240,000 × 8	1,920,000
Difference in favour of stability	1,470,000

Strain upon the Knee Braces.

Let ACBD represent the cross section. The effect of the pressure of wind on AC is equivalent to half that pressure applied at the point A. A force at A tends to produce rotation around B and C, which may be resisted by a brace in the direction of the diagonal AB. The pressure upon the brace will bear to the force at A the proportion of the diagonal to the side AD. If the brace be removed the pressure must nevertheless still continue; and if it be resisted by a brace *ef*, the pressure upon *ef* will be greater than that upon AB in the proportion of AD to *e*D; because D is a fulcrum, and AD and *e*D the leverages of the acting and resisting forces. If *ef* is parallel to AB, which is generally a very favourable direction, the lengths *ef* and AD will be in proportion to the distances De and DA, and may be substituted for them. In the present case the force of wind, 45,000 lb, acting with a leverage of 10 feet, will give its moment 450,000 lb, or 225,000 lb acting at a distance of 20 feet. The length of the diagonal is $\sqrt{20^2+16^2}=25{\cdot}6$ feet, and the strain in the direction of the diagonal $\frac{22,500\times 25{\cdot}6}{16}=36,000$ lb. The length of the knee-braces being 5 feet, the strain upon them will be $36,000\times\frac{25{\cdot}6}{5}=184,000$ lb. This is resisted by fifteen braces (one to each post). The cross-section of each is 25 square inches; but as the bearing surface of the joint does not extend over the whole surface of the section, the resisting portion will be reduced to 15 square inches. The strain per square inch will therefore be $\frac{184,000}{15\times 15}=818$ lb. For the resistance to flexure of the fifteen braces, $w=\frac{9000\times 5\times 5^3}{5^3}\times 15=3,375,000$, or about 20 times the pressure.



The strain upon the bolts at D will be to the vertical component at A in the proportion of De to eA, or as 5 : (25·6—5). The vertical component at A = 22,500 = $\frac{AD}{AC}=22,500\times\frac{16}{20}$ = say 17,000. Hence the strain upon the 15 bolts will be 17,000 × 4 = 68,000, or 4533 lb. to each bolt, or 10,000 lb. per square inch if the bolts are ¾-inch in diameter.

Pressure upon the Arch.

For this calculation we have, from the table of data,—span 148 feet; distance of centre of gravity from abutment 37 feet; rise of arch 20 feet. Proportion of hypothenuse, perpendicular, and base of skew-back, 18, 16, and 7·6. Cross-section of eight arches, 800 square inches.

$800\times\frac{16}{18}=711$ proportion to resist horizontal thrust at skew-back.

$800\times\frac{7{\cdot}6}{18}=338$ square inches to resist vertical pressure at skew-back.

The weight for one half span loaded is 275,000:

$$800\times 20\times P=275,000\times 37.$$

P = 448, pressure per square inch on arches in middle.

The resisting cross-section at the skew-backs is the same as at the crown. The pressure is greater in the proportion of the hypothenuse to the perpendicular: it will therefore be $448\times\frac{18}{16}=504$ lb. The arches are therefore more than sufficient to sustain the whole weight.

When both systems act as one,—the data required to determine the strains upon the chords and arches are,

Distance from middle of upper to middle of lower chord ...	19 feet
Distance from middle of skew-back to middle of lower chord	4·2 ,,
Distance from middle of top chord to middle of arch ...	3·5 ,,
Cross-section of upper chords	400 sq. in.
Cross-section of lower chords	280 ,,
Cross-section of arch at crown	800 ,,
Cross-section of arch at skew-backs	711 ,,

Let x = distance of top chord from neutral axis.

$x-3{\cdot}5$	,,	arch at crown from neutral axis.
$19-x$	,,	bottom chord from neutral axis.
$23{\cdot}5-x$	,,	arch at skew-back from nextral axis.
P	= pressure per square inch on top chord	
$\frac{P}{x}(x-3{\cdot}5)$	,, ,,	arch at crown.
$\frac{P}{x}(19-x)$	,, ,,	bottom chord.
$\frac{P}{x}(23{\cdot}5-x)$	,, ,,	arch at skew-back horizontally.

The equations in this case are

$$400Px+\frac{P}{x}800(x-3{\cdot}5)^2+\frac{P}{x}280(19-x)^2+\frac{P}{x}711(23{\cdot}5-x)^2=275,000\times 37$$

and $$400Px+800\frac{P}{x}(x-3{\cdot}5)^2=280\frac{P}{x}(19-x)^2+711\frac{P}{x}(23{\cdot}5-x)^2.$$

From the second of these we find $x=11{\cdot}8$. Consequently the distance of the neutral axis will be

Below top chord	11·8 feet.
Below arch	8·3 ,,
Above bottom chord	7·2 ,,
Above skew-back	11·7 ,,

These values substituted in the first equation will give $P\times 222,000=7,175,000\times 11{\cdot}8$, or

P = 381 lb. = pressure per square inch on top chord.

$381\times\frac{8{\cdot}3}{11{\cdot}8}=268$ lb. = pressure per square inch on arch at top.

$381\times\frac{7{\cdot}2}{11{\cdot}8}=232$ lb. = strain per square inch on lower chord.

$381\times\frac{11{\cdot}7}{11{\cdot}8}=377$ lb. = strain per square inch on perpendicular of arch at skew-back.

Vertical Pressure.

Assuming that the weight sustained by each system will be in proportion to its power of resistance, the greatest weight that the truss can sustain will be the limit of flexure of the braces in the end panels. This has already been found to be 223,000 lb., which will be produced by a vertical pressure of $\frac{223,000\times 15{\cdot}5}{17{\cdot}7}=195,282$ lb.: this is the extreme limit of the power of resistance of the end braces.

The proportion of surface at the skew-back which resists the vertical pressure is 388 square inches. If we suppose the vertical pressure on the base of the skew-back to be the same per square inch as the horizontal pressure upon the perpendicular, it will be capable of resisting 186,830 lb.: this, deducted from the whole pressure ... ... 275,000 ,,

will leave for the portion to be sustained by the braces ... 94,170 lb. which is below the resisting power. The actual limit of the resisting power of the arch is very great; but assuming that in practice it is not safe to exceed 1000 lb. per square inch, the proportions of the weight sustained by the truss and arch would be,

For the truss $275,000\times\frac{108,663}{338,000+108,663}=66,880$;

And for the arch $275,000\times\frac{338,000}{446,663}=208,000$.

These numbers will give for the strain per square inch on the arch $\frac{206,100}{338}=615$ lb. For the end braces $\frac{66,880\times 17{\cdot}7}{15{\cdot}5\times 216}=353$ lb.

It has been stated that the bridge at the western end is sustained by an abutment-pier: it is proper to examine whether the resistance which that is capable of opposing is sufficient to counterbalance the thrust of the arch, on the supposition that it should bear the whole of the load.

The dimensions of the abutment-pier are given in the accompanying figure, except the length, which may be taken at 16 feet.

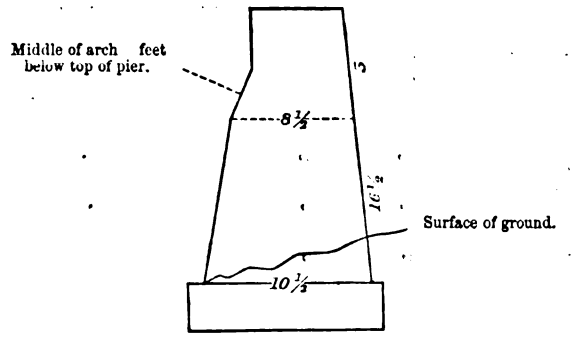
We will examine the conditions of equilibrium on the supposition that rotation takes place around the point B. The disturbing force is the horizontal component of the thrust of the arch = 358,750 lb. acting with a leverage of 16½ feet: its moment will therefore be $358,750\times 16\frac{1}{2}=5,919,375$. The resistances are—

1. The weight of the masonry above CB = 110 perches, of 3750 lb. = 412,500 lb. The distance of centre of gravity from B is 5 feet; the moment will be 2,062,500.

2. The adhesion of the mortar, estimating it at 50 lb. per square inch,

Digitized by Google

or one-half the tabular strength of hydraulic cement, will be, on a surface of 160 square feet=1,152,000 lb., and its moment, with a leverage of 5 feet=5,760,000 lb.



3. The vertical pressure of the arch itself, 275,000 lb., acting with a leverage of 9 feet, will give a moment 275,000×9=2,475,000.

The sum of the moments of the resisting forces will be ...	2,062,500 5,760,000 2,475,000	
Total		10,297,500
Moment of disturbing force		5,919,375
Difference in favour of stability		4,378,125

As this difference is less than the adhesion of the mortar, it appears that an abutment pier of dry masonry of the same dimensions would be overturned.

It has been supposed, in this calculation, that the arch bears the whole weight, and that the abutment resists the whole thrust. The actual horizontal thrust, with the two systems acting together, was found to be 377×711=268,047. The moment will be 268,047×16½=4,422,775. The resistance, omitting the strength of the mortar=4,537,500. From which it appears that if we disregard the adhesion of the mortar, the system as a whole would be very nearly in a state of equilibrium, the difference being in favour of stability. The practice of the writer in proportioning abutments on rock foundations is, to disregard the adhesion of the mortar, throwing this, whatever it may be, in favour of stability: there is so little uniformity in the strength of mortar, and so much liability to cracks occasioned by jars, when partially set, that it is not safe to depend much upon it. If the proportions and weight of an abutment do not prevent it from overturning without taking the strength of the mortar into consideration, it is too weak.

When the base is to any extent compressible, it is not sufficient that the disturbing and resisting forces should be in a state of equilibrium—a condition which requires the resultant of all the forces to pass through the point of rotation; but it is proper that the resultant should pass through the middle of the base. This calculation was made before the completion of the bridge: the correctness of the conclusions was soon confirmed: the pier began to crack after the opening of the road, and an increase of thickness by the addition of buttresses was found necessary.

Summary.

Span	148 ft. 3 in.
Width of pier on top	3 „ 2 „
„ „ skew-back	6 „
Timber in one span	72,726 „
No. of cubic feet per foot lineal	40 „
Width from out to out of chords	20 „
„ middle to middle of chords	19 „
Versed sine of lower arch...	20 „
Radius	17,255 „
Weight of timber per lineal foot	1416 lbs.
Weight of iron in one span	5280 „
Weight of half-span loaded	275,000 „
Strain upon floor beams per square inch...	952 „
„ lateral brace-rods per square inch	3444 „
„ lateral braces	571 „
„ knee-braces per square inch	818 „
Pressure per square inch on top chord	381 „
„ „ „ arch at crown	268 „
„ „ „ lower chord	232 „
„ „ „ arch at skew-back	615 „
„ „ „ end-braces	353 „
„ „ „ middle-braces	260 „

Practical Tunnelling, by F. W. Simms, M. Inst. C.E. Revised by W. D. Haskoll, C.E.—London: Batsford, High Holborn.

The present is the second edition of this well-known and useful work. It has been carefully revised, and several plates have been added to those already illustrating the work. These consist of Plate 13, sections and plan of a tunnel entrance on the Wilts, Somerset and Weymouth Railway, for a double line. Plate 14, elevation, sections, and plan of a tunnel on the South Wales Railway, having semi-eliptical retaining wing walls. Plate 15, elevation, sections, and plan of a tunnel constructed on the Manchester and Leeds Railway, through rock, for a single line of rails. Plate 16, elevation, sections, and plan of the Birkenhead tunnel, which is for a single line of railway. A description of these plates added to this edition is given in an "additional appendix." The improvements and additions which have been made to this work will, we doubt not, render it very acceptable to the profession.

UNDER SUNK FOUNDATIONS.*

By C. I. Spencer, Resident Engineer of Chunar Division, East India Railway.

The following remarks on the subject of well sinking in bridge foundations embody the experience gained in sinking the foundation wells of a bridge over the Jurgoonullah, a hill stream which runs into the Ganges a few miles below Chunar.

Such knowledge being derived from one job is necessarily partial and limited, and is only offered as a contribution towards the general stock of information wanted on a very interesting subject; and I shall be thankful to any one engaged on similar works who will correct, from more complete information, any erroneous conclusions I may have come to, or raise a discussion on any doubtful point.

The Jurgoo well-sinking, which was commenced in October 1857, has just been brought to a successful termination, and what few mistakes were made at starting in points on which we had not the light of experience to guide us, have not involved any serious ill consequences, and are now fruitful of instruction.

In deciding upon the use of under-sunk foundations in preference to piles, coffer-dams or any other expedient, it is necessary to take into consideration the form and material of the bed of the river to be bridged, the floods to which it is subject, and their tendency to scour to any given depth.

In these particulars the Jurgoonullah is so circumstanced, as to render it unsafe or difficult to use any other kind of foundation than the one adopted. The bed at the point bridged, consists almost entirely of sand, gravel and other loose drift material, to a depth of about 20 feet, below which occurs a stratum of pure white sand of unknown thickness, which extends under the strong kunkury clay at the banks of the nullah, and has evidently never been disturbed by the action of the stream.

The stream itself is a mere hill-torrent, rising above 20 feet in two or three hours and falling again as rapidly; in the dry weather it does not rise above its bed, but stands in pools in the sand. Besides the hill floods the nullah is subject to overflow from the backwater of the Ganges, and the alternating and sometimes combined action of these floods gives rise to alternate scourings and fillings of a kind very difficult to foresee or provide for.

The only certain principle therefore upon which it was possible to proceed was to assume that what the water had done it would do again, that the scour would reach on some future occasion the depth it had reached before, and having ascertained this limit, to sink the wells to what might be considered a safe distance below it, and there leave them in the white sand which there appeared no hope of getting to the bottom of.

In such a situation piles would have been useless, the stuff would have been washed out from between them, and the bridge been left standing on the naked sticks; sheet piling could never have been driven deep enough to defend them from the scour, and to have sunk copper dams 30 feet into the bed, dredged out the stuff, and filled the bottom with concrete, might have been a safe plan, but would certainly have been a tedious and expensive one.

Having then once determined on the use of wells, the next thing was to find out the proper dimensions and arrangement, as well as the best form of curb and mode of attaching it to the

* From the Calcutta 'Engineer's Journal.'

Digitized by Google

masonry. In all these particulars, the one great object to be attained is to make a well which shall *sink*, for if by any accident or defect in design or construction, one of the wells should stick half way and obstinately refuse to budge an inch, a contingency which sometimes happens, it is next to impossible to get it out again, and the engineer may be placed in the unpleasant position of having to alter his design and begin foundations in a new place.

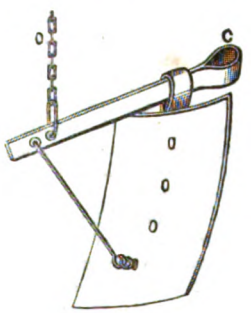
Before considering the causes which tend to impede the descent of wells, I shall describe the different modes adopted for sinking them.

In every case the first step is to lay the curb on the surface, as low down as possible, and build the well to a height above it, equal to somewhat less than its own diameter; the sand and stuff is then cleaned out from the interior and leaves a hollow into which the well sinks. For the first few feet the men can stand in the water and lift the sand out easily enough, but as the well gets deeper, it becomes necessary either to get rid of the water or to contrive some way of working under water.

The first plan, viz., getting out the water, is when feasible by far the most speedy and satisfactory, and it may sometimes be advisable even to go to the expense of a steam engine to work the wells dry. Where this cannot be done, or where the quantity of water is not so great as to require it, the pumping may be done more awkwardly, but more cheaply, by means of buckets and pullies worked by coolies. A large amount of the Jurgoo well-sinking was done by these means: two or three leathern buckets or rather bags *(mhotes)*, each pulled by eight or ten coolies, were let down each well, and with European superintendence and energetic driving, it was found possible in most cases to lower the water in three or four hours sufficiently for the men to stand in it.

2. When the water cannot be got low enough, or even while it is in process of lowering, the stuff may be got out by means of divers, who go down with a small iron plate with which they shovel the sand into a basket, which when full is drawn up by a couple of women. The divers stay about 15 seconds under water, and will often fill a basket at one dive, but they soon get tired, and it was found necessary to have four relays of them every day, and to pay each of them four annas per diem, or about three times the pay of an ordinary coolie.

3. The jham is used in cases where the water cannot be lowered and is too deep for divers. It consists of a plate of iron about 2 feet square; at the upper end is a collar C, into which is inserted the end of a pole which is about 4 or 5 feet longer than the depth of the well: the jham with the pole fixed is dropped with some force on to the bottom of the well, and the pole is moved about by the men above, so as to work the edge of the iron as deep as possible into the soil. The chain O is then drawn up by means of a windlass, the collar C disengages itself from the spindle end of the pole, the lower end of the shovel is lifted up, and the jham plate hangs like a scale pan, with a certain, or rather a very uncertain, quantity of stuff in it. This has to be lifted slowly and carefully, so that the water may not wash it away. When it reaches the mouth of the well the contents are drawn out, the pole fixed, and the whole contrivance dropped once more to the bottom.



The jham works sometimes very well in sand and loose material, and I have seen them at the Jumna coming up with about a cubic foot of stuff on them; but it is at best a capricious thing, and often comes up empty or with the merest spoonful of earth on it, especially when used to get up hard clay or kunkury sand. I do not know who was the inventor of this singular instrument, but he must have been in India a long time, and have got the idea of a codalee irretrievably fixed in his mind. It is however, as far as I know, the best instrument that has yet been invented for the purpose. I have seen dredges tried, but never heard of one being applied successfully. There was one tried at the Jurgoo, but the buckets had a trick of getting upside down, or hind part before, or any way but the right one. They have, I believe, been since tried at the Jumna, and it would be interesting to know how far they have succeeded. The one used at the Jurgoo consisted of a set of small scoops or buckets fastened at intervals of about 2 feet along a couple of ordinary chains, which passed round a couple of rollers at top and bottom of a square frame inside the well; one of these chains was constantly gaining on the other, and the buckets getting tilted up at one side. To obviate this I would propose making each pair of links the full length of the distance between two successive buckets, and making the roller of a polygonal form, each side being equal to the length of one link.

I do not however think that a dredge is the thing required for well-sinking. It is too large and too heavy, and takes too much time in fixing and lengthening, and is too expensive in proportion to the total cost of sinking. What is wanted is some machine that can be worked like a jham at the end of a pole, but which will be more certain in its action and less liable to come up empty —something which can be lifted out of one well into another easily and readily without carpenters, and not keep all your coolies waiting for more than half an hour at most.

I submit the question to the ingenious among your correspondents: if any of them can solve it in a good, practical, practicable form, he will supply a great desideratum in Indian public works.

Such are the chief methods which have been employed to sink the Jurgoo wells.

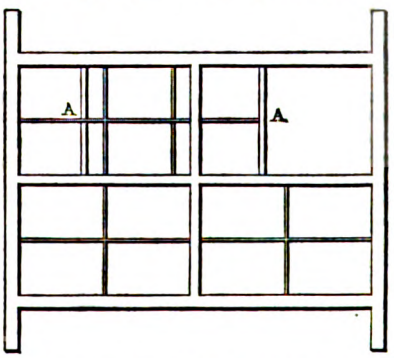
ON AN IMPROVED COTTAGE WINDOW.*

By the Hon. Lord Murray.

Few thinking persons can have visited many dwellings of the poor in the northern and western parts of the country, without being pained by the want of ventilation in their rooms generally, and the bed-rooms in particular. What with the size of such apartments being small, and the window too often a mere bit of glass built into the wall, the contained air is necessarily stagnant; and under the influence of respiration it becomes rapidly offensive, and even deleterious.

Of course this is not the first time that attention has been called to so pregnant and constant a source of evil; and for its radical cure windows have been made to open in various ways, as on a hinge or in the sash way. But the cottagers complain of the first, that if they open the window at all they must open it to the full, be the day boisterous or be it calm; and if when put fully open they neglect to fasten it there, a gust of wind sends it swinging about until the hinges and glass are broken. And of the second method they say, that the ropes, pulleys, weights, &c. are always getting out of order, and unless expense be incurred, the sash soon becomes immoveable.

To meet these difficulties and objections I have contrived a method whereby one-fourth of the whole window A A (see figure) say the upper right hand corner, slides horizontally to or from its place past the upper left hand corner between two grooves: one formed by the upper part of the general window frame, the



other by a crossbar running along the middle. This plan has the advantage over the hinge, that the amount of opening can be varied at pleasure, without any special means of fastening; and over the sash plan, that it has no machinery that can get out of order, and the trouble of opening it is so small that there is a hope of the inmates being thereby prevailed on to use it.

The size shown in wood might perhaps be a boon to many a poor cottage bed-room; but for their other rooms, and hoping for

* Paper read at the Royal Scottish Society of Arts.

Digitized by Google

their general improvement also, I have had a cast-iron window-frame constructed, 3 feet by 4 feet in size, with the peculiar sliding panel already described. The expense of constructing the founder's model having been once gone through, I am in hopes that the cost of further castings may be greatly reduced; while the facility of building the ready-made cast-iron frame into a stone wall, and then the lasting nature of it, may afford a cottager the means of purifying and ventilating his dwelling at the smallest possible cost, and in the easiest possible way.

The leading features of this modification of the principle are summed up in the following notice, which I have had printed for public distribution:

CAST-IRON COTTAGE WINDOW, MEANT TO GIVE AMPLE LIGHT AND SUFFICIENT VENTILATION AT A SMALL EXPENSE.

Three quarters are glazed and fixed. One quarter slides horizontally. There are no pulleys, ropes, or hinges.

Size.—Breadth 2 ft. 9 in. by 3 ft. 9 in.

Castings.—It might be possible to cast it in one piece, but—1, one casting built into the wall; 2, a small frame or slide; 3, a frame closed with screw-nails to hold the slide—will be more easily cast separately.

Glass.—For a fine sea view four panes of plate glass might be used; but for common use sixteen panes will be better. If broken they may be replaced for about a penny. Care must be taken to provide for expansion by heat.

THE ATLANTIC TELEGRAPH.

THE Atlantic Telegraph Company, being desirous of ascertaining the present electrical and mechanical condition of the Atlantic cable, recently deputed Mr. F. C. Webb, C.E., to proceed to Valencia, for the purpose of making the necessary experiments upon the cable. Mr. Webb, who has had great experience in telegraphic engineering, has made the following report:

"*To the Chairman and Directors of the Atlantic Telegraph Company.*

Valencia, Aug. 10.

Gentlemen,—According to your request I have made from Valencia a careful examination of the electrical state of the Atlantic cable. I made some tests for comparison on the various pieces of Atlantic cable in Messrs. Glass's premises at Greenwich during July 31 and August 1.

I arrived here on the 4th inst., and, assisted by Mr. Collett, made experiments during the 5th, 6th, 8th, and 9th inst. I find the lowest resistance shown to be 278 statute miles. I find it is possible to increase this resistance up to 589 miles by sending a copper current for some time from six 12-plate Daniel's batteries.

By experiments I have made on various kinds of constructed faults I find that a fault which could be thus oxidised so as to give (by reversal of the current) a difference of resistance equal to the difference obtainable on the cable, viz., 311 miles, must give a minimum resistance of about 16 miles. When the fault is large, and thus gives little resistance, no great change can be obtained by reversing the battery; and, indeed, it is evident that when the connection between the line and earth is increased beyond a certain extent of surface no difference in the resistance of the circuit can be obtained by reversing the battery. When the fault is very minute it can be almost perfectly sealed up by a copper current, but the resistance will still be very great, even with a zinc current.

My experiments show that a fault of about 16 miles, minimum resistance, can be varied with certainty by reversal of the battery to the same degree as the fault in the cable, and that if the fault gives less resistance than 16 miles it cannot be varied to that extent, while if it gives more resistance the variation cannot be produced with the same certainty, nor quite to the same degree. Taking therefore the resistance of the fault and cable beyond the fault to be equal to 15 miles, this would bring the fault to about 263 statute miles from Valencia.

As I have no information of the return current due to different lengths of the Atlantic cable, which might have been observed and tabulated during the paying out of the cable, it is impossible to check the resistance tests accurately by the observed return current. Comparing it, however, with the return current on the Cagliari and Malta and Corfu cables, and making, roughly, allowance for the increased size of the gutta-percha in the Atlantic cable, I find it to be about what is due to the supposed distance of the fault.

I also made experiments on the return current with a wire leading to earth from the cable, and by placing resistances in circuit in this wire I could represent a fault close at hand and of varying resistance. I found that in such an arrangement, when the artificial fault gave a resistance of 300 miles, the return current was only reduced about 22 per cent. If the real fault, therefore, was close at hand, the return current of the whole length of perfect cable beyond the fault would be only reduced about 22 per cent. also.

I am of opinion that the observed return current is much less than 78 per cent. of the return current due to the whole cable, as it would be if the fault were close at hand, and of a resistance of about 300 miles, and that it coincides, as nearly as I can judge, with that due to the length shown by the resistance.

Again, when the artificial fault was made to represent a resistance of 260 miles, and then increased to 580, the return current only increased about 17 per cent., whereas when the real fault is increased to the same amount of resistance (by sending a copper current for some time) the return current increases about 80 per cent. This shows also that the return current is more influenced by the partial healing of the fault than it would be if the fault was a small one near at hand, and consequently tends also to confirm the supposition that the fault is distant, and offers, when at its minimum, little resistance.

I am of opinion, therefore, that a serious fault exists about 263 statute miles from Valencia, measured along the cable, and that the cable between that spot and this shore is comparatively perfect.

No tests from here can now decide whether the cable is mechanically severed, since all attempts to detect the reception of the most intense currents from the opposite shore have long since proved fruitless. Still, from the various circumstances attendant on the decline of the insulation, there is every reason to believe that the continuity both of the cable and the conductor is perfect. Whether any other faults exist beyond the one alluded to, it is impossible to ascertain by tests from Valencia.

The fact that the signals received at Valencia were always better than those received at Newfoundland, proves undoubtedly that the worst insulation has always been near Valencia; and therefore it seems probable that if the fault which exists on this coast, and which, very likely, forms the principal cause of leakage, could be removed, the insulation would be so far improved as to render the cable again available for signalling, provided the fault which is said (by those who have tested from Newfoundland) to exist in Trinity Bay was also repaired.

I have &c., F. C. WEBB."

THE DOCKYARD AND ARSENAL OF TOULON.

DURING a recent visit to the famous dockyard and arsenal of Toulon by a correspondent of the *Times*, the following interesting particulars were obtained:—

The new large smiths' shop in the dockyard, commenced in 1840 and finished three years afterwards, contains 96 forge fires, besides four larger ones in a neighbouring building to heat the iron for a steam hammer. The blowers and hammer are worked by a 20-horse power steam engine. It soon became evident to the authorities that the space inclosed within the walls of the arsenal was too limited to allow of the development contemplated. Accordingly the timber stores, building slips, sawing machinery, and block factory were transferred to a faubourg of Toulon, called the Mourillon, situated on the opposite or eastern side of the inner roadstead. The space thus gained was still found insufficient, so rapidly did the desire grow among successive governments to possess a powerful fleet. The district lying beyond the arsenal walls towards the south-west, and known under the designation of Castigneau, was determined to be included, and it is on this new site that the most important works, which date from the Second Empire, are being carried out. At Castigneau three graving or dry docks are in course of construction, calculated to receive the largest vessels of war. The largest dock, nearly 400 feet long, is now finished with the exception of the gates. It is built in the most substantial manner, and faced with massive slabs of beautiful red and grey granite. The mode employed in building these docks is peculiar. They are situate on what formed the beach of Castigneau, which rapidly shelved down into the deep water of the roadstead. The buoy off the entrance to the docks shows a depth of nearly 40 feet, quite sufficient to allow of the passage of vessels of the heaviest draughts at all times, which is absolutely necessary in the Mediterranean, where the rise and fall of the tide never exceeds a few inches. From the character of the soil where the docks are constructed it was evident that the ordinary system of foundation could not be employed, and to have recourse to piling would necessitate too great an expenditure. The engineer was induced to use concrete in a novel manner. The site of the dock appears to have been excavated, and a solid bottom of concrete formed several feet in thickness. Concrete was next used to form the retaining walls at the sides and end, and even at the end where the gates are to be placed. When the walls were brought up to a sufficient height above the level of the sea, the water inside the dock thus rudely formed of concrete was pumped out, and the structure faced and finished off with granite in the usual way. The labour and expense of excavating were considerably reduced by building a portion of the entrance end of the docks out into the sea. The system followed was analogous to the one used with such success

Digitized by Google

by Mr. Page in building the piers of New Battersea-bridge. Timber piles were driven with sufficient space between the rows to allow of retaining walls being formed therein by throwing in concrete. When the space wherein the dock was to be built was inclosed by the concrete walls, the water was pumped out, and the granite construction proceeded with. The mass of concrete across the entrance to the finished dock was being bored with vertical holes, about 2 inches in diameter, by the aid of machinery similar to what is employed in boring artesian wells, and driven by a small portable engine. It was not ascertained whether these holes are intended to admit of the concrete mass being blasted into fragments for subsequent removal; but, if so, the process must be attended with danger to the structure of the dock itself. Although it may be more costly, it would have been safer to employ a common cofferdam for this portion of the work—to fill up the entrance and to exclude the water from the inside. In forming the concrete walls the ballast was brought down from the excavations for the foundations of the new structures at Castigneau, in small waggons running on a moveable railway. The waggons were made with the bottom fixed from the top of one side to the lower part of the other, which latter opened outwards on hinges. By this means, when the ballast waggons were brought on to a scaffold fixed above the water, and where the mixture was to be effected, the attendant had only to allow the side to fall down, when the ballast discharged itself by its own gravity, and there was no time lost in tilting. The lime and sand were first mixed in a species of pugmill, worked by a portable steam engine, and then discharged on to the ballast, with which it was mixed by hand. The men who fed the lime into the mixing mills had their mouths and noses carefully protected by linen cloths; but in spite of these precautions they suffered severely in consequence of inhaling particles of lime. When the ballast and lime were intimately compounded the whole was discharged down a shoot into a boat, which conveyed it to the spot where it was to be thrown into the water.

Among the new buildings erected for workshops is a large structure filled with horizontal planing machines, of the latest and most approved construction, from the factory of Messrs. Cail and Co., Paris. The vertical revolving plate of a turning lathe was upwards of 13 feet in diameter. A second structure was fitted up as a smiths' shop, with the forges arranged in pairs, and some in fours. There were not less than 50 fires, and room for as many more. A third structure fitted up as a foundry, has furnaces arranged in four pairs on either side. The furnaces are marked to contain 10 tons each—there are 16 of them, allowing 160 tons of metal being melted at the same time—more than would be required for the largest casting.

The Gloire and Invincible steam frigates, cased in iron, are rapidly approaching completion. They are sister ships. The principal dimensions are: length, 252 feet; beam, 45 feet; breadth between ports, 8 feet; thickness of sides on the main deck, independently of iron facing plates, 26¾ inches. The timbers are of the largest dimensions, such as are used in line-of-battle ships. The beams for the main deck are 16 inches by 17 inches square, partly supported by columns of rolled iron, of small diameter, stepped on the kelson. On a portion of the main deck of the vessel, examined on the port side of the main hatchway, the timber beams were replaced by iron girders, with apparently great economy of space, and equal if not greater strength. The vessel is pierced with 20 ports on a side. The iron plates for sheathing her sides are rolled iron, 4¾ inches (12 centimetres) in thickness, 3 ft. 7 in. wide, by 4 ft. 6 in. long. This would make the weight of each plate nearly 1 ton 6 cwt. The plates are to be bolted to the frigate's sides from the line of flotation up to a level with the upper deck. Besides the side plates, the frigate is to have her upper deck covered with iron plates ¾ths of an inch in thickness. They are to be bolted between two decks, or horizontal layers of timber, with a view to making her bomb-proof. This additional weight must tend to increase her topheaviness.

Toulon possesses, or will shortly possess, six dry docks, seven building slips covered, ten building slips uncovered, with a foundry and mechanical appliances sufficient to build, equip, and maintain a far more formidable fleet than France has ever possessed hitherto in the Mediterranean; while, in addition, the private yards and engine works of La Seyne and La Ciotât are close at hand, and capable of being made available at any time.

The Lave floating battery is 225 feet long, and has the dimensions, in other respects, of a first-class frigate. She carries 18 guns, larger than our 68-pounders apparently, and only fights one broadside at a time. Her sides are faced with iron plates about 3 inches thick, from the water line up to a level with her upper deck. The bulwarks are made to fall down, the funnel to sink below the upper deck, and the masts to disappear, on going into action. The screw is well below the water, and safe from shots. The engines are below the water line. In fighting the battery there is nothing but her hull to fire at, and that is protected by shot-proof plates. The crew are all on the main deck, and out of harm's-way, with the exception of the officer in command. He stands upon the upper deck, and gives his orders for the management of the battery and working of the guns to the officers on the main deck by means of speaking tubes. The commanding officer is consequently exposed to the enemy's shot, and to protect himself the captain of the Lave has devised an ingenious expedient, which has still to be tested. It consists of a cylinder of timber, about 7 feet in diameter and the same in height. The circumference of the cylinder is coated with iron plates, about half an inch thick, and from the centre projects a spar which fits into a hole made in the deck, and serves to keep the cylinder in position. In action the officer keeps behind the cylinder, against which the shots striking will glance off, while he can shift his position for the purpose of observation as required. Gratings hook on to the side for riflemen, who are protected by the whole breadth of the deck. Although these constructions have been tried to a certain extent in the Black Sea, it is considered doubtful whether they would answer so well in a general and sustained action. The between-decks must rapidly fill with smoke and heat, so as to be insupportable, from the absence of scuttles. Even on a summer's afternoon the ventilation was most defective, and the temperature overpowering. The crew said they suffered much from these two evils, which must almost counterbalance the advantages presumed to be derived from the iron sheathing.

The Coudon is a good specimen of the new light draught gunboats. She is about 68 feet long, and 15 feet beam. Her engine is 16-horse power, and is fixed in the stern, occupying, with the boilers and furnaces, about one-third the length of the vessel. The screw is hardly so well protected as it might be. The officers' cabin is amidships, in front of the engine-room, and is most unpleasantly hot. The forecastle occupies the remainder of the vessel, and, besides berthing the crew and storing provisions and water, contains the shell in lockers. Her crew consists of 16, including the officer in command, master, gunner, engineer, stokers, and seamen. Her armament consists of a rifled 30-pounder, which is worked behind a shield, plated with 4½-inch iron, constructed in her bows. The shield, in this instance, is the height of a man, and the bulwarks between it and the stem are unshipped in action. The deck where the carriage worked was planked over, to obtain increased strength, and to allow of an angle being formed to offer resistance to the running in of the gun. Nevertheless, the recoil, it was stated, was the greatest practical difficulty with which the men had to contend, from the want of space to stand clear in working. The shell fired from this gun is of cast-iron; it resembles in form and size a loaf of white sugar, with the sides straight for three-fourths of its length; it weighs 57 lb., and is filled with the bursting charge through an orifice in the apex. A plug is screwed into the orifice and projects outward a short distance. Through this portion of the plug a hole is drilled, through which a short lanyard is passed, to facilitate handling. On the circumference at the centre of gravity are the three *ailettes*, or feathers, for fitting into the grooves of the gun. They consist of projecting pieces of iron, cast with the shell, about 2½ inches long, half an inch broad, and rising about a quarter of an inch above the surface. In front of each *ailette* zinc has been run in flush with the top of the latter, and then cut down anglewise to a point of the circumference the distance from which point to the back of the iron projection is equal to the breadth of the groove. By this arrangement it is the zinc which bears against the edges of the groove inside the gun. With the slightest sea on the gunboat is found to be dangerously topheavy. In being towed back from the Adriatic, it was found necessary for the safety of the vessel to unship the gun, and, what was worse, to remove the upper iron plates from the shield in the bows. Evidently the problem has still to be solved.

Digitized by Google

ST. MARY AND ST. MICHAEL'S CHAPEL, CATHOLIC CEMETERY, KENSAL GREEN.

(*With an Engraving.*)

As will be seen by the plan, the chapel consists of a nave 25 feet wide and 54 feet in length, including the apse. The entrance is by the south porch, which is so constructed as to have double doors opening in the thickness of the arch, avoiding the usual ugly expedient of projecting bulkheads; on the north side, near the east end, there is a sacristy, connected with the chapel by a lobby with external entrance, the lobby serves also as an office for the registry of the burials.

Access to the vaults, which extend beneath the nave of the chapel and cloisters, is provided for by a flight of steps opening out of the cloisters at the west end of the chapel: the coffins are lowered into the vaults by an apparatus placed in the centre of the nave. The belfry is placed over the entrance to the catacombs, so that the bell can be tolled from the cloisters.

The west front presents a large cross constructed in the masonry, the stem forming the division between two single-light windows, and the arms spreading out across a circular window which forms a nimbus to it, beyond the circle the arms of the cross terminate with floriated ends.

The apse, semicircular on plan, is covered internally with a semi-dome pointed in section, constructed with tiles, and designed to receive a fresco painting. To avoid the inconvenience of a glare of light in the eyes of the priest and congregation, the windows are placed at the side of the apse only, the space behind the altar being decorated with a fresco painting by Mr. Westlake. Externally the apse is covered with a polygonal roof, terminating with a metal cross, and is strengthened by a buttress facing the principal entrance to the cemetery, and supporting a canopied niche containing a statue of the Virgin and Child, carved by Mr. Phyffers. The altar consists of a stone slab with polished alabaster cornice, resting at the angles on columns with serpentine shafts, and supported at the centre by a moulded and carved pier inlaid with marble mosaic, forming a cross. Resting on a step for the crucifix and candlesticks, inlaid with alabaster, there is a low reredos surrounded by a carved stone frame and inlaid with marbles and alabaster; in the centre the crown of thorns and nails are carved in alabaster, and on each side there is a bust of an angel in an attitude of devotion: the reredos is richly carved with flowers, &c. in relief, the flat surfaces being inlaid with marble mosaic. The whole is designed on the model of the Mediæval Italian altars, affording scope for the introduction of much novelty in design by the combination of carved stonework in relief, and flat surfaces in the coloured materials now so readily to be obtained by the architect at a moderate cost. With this exception, the whole of the interior of the chapel is left perfectly plain for decoration by the monuments which are expected to be placed on the walls, and for which a general design has been prepared by the architect.

The cloisters form a protection to the vaults beneath, and are intended to receive mural tablets. The vaults are divided into compartments by stone divisions, so that each coffin is separately inclosed in stonework; the inscription stone serving as a seal to close the whole permanently.

The walls are constructed with Kentish Rag with Bath stone dressings, bands, &c., and Portland stone crosses.

The cemetery includes an area of 30 acres, laid out and drained in accordance with the government instructions, and provided with a lodge and office in character with the chapel, and with a large mortuary cross in the centre of the ground, the base of which, richly carved in Portland stone, rests on steps raised on a mound, and carries a polished granite shaft and capital, carved with foliage and angels supporting a boldly sculptured group, representing our Lord on the cross with the Virgin and St. John standing by. The sculpture was executed Mr. T. Phyffers.

The whole of the works have been executed from the designs and under the superintendence of Mr. S. J. Nicholl, architect, London; the contractor being Mr. G. Smith, of Pimlico.

References to Plan.

A. Sacristy.
B. Sacristy Vestibule.
C. Cloister.
D. Stairs to Catacombs.
E. Apparatus for lowering the coffins.
F. Stairs to chamber below the Sacristy for warming apparatus.

NEW CHURCH, MARAZION, CORNWALL.

(*With an Engraving.*)

This church, now in course of erection, is Geometrical in style, of the early second pointed period: it consists of chancel, 25 ft. 6 in. by 17 feet; nave, 54 feet by 18 feet; south aisle, 54 feet by 14 ft.; vestry, 13 ft. by 8 ft.; north porch, 10 feet by 9 ft. 6 in.; with single bell cot rising from the north-west angle of nave, and partially supported on west gable.

The structure is of Elvin stone in random courses, granite being used for the external work in dressings to doors, windows, copings, buttress weatherings, &c. Internally Bath stone is to be employed in the piers and arches, dressings to doors and windows, chancel arch, corbels, &c. The floor of chancel and central passages between seats in nave and aisles are to be paved with tiles from the Poole potteries, of three colours, arranged in patterns. Open seats with solid ends are to be provided for the nave and aisle, the school children occupying the eastern portion. The chancel, divided from the nave by an arch spanning its entire width, is to be raised by three steps, and fitted up with seats and book rests for the clergy and choir. An oak rail supported by wrought-iron standards for the use of communicants, separates the apsidal portion, and will contain the oak altar table, credence sedilia and piscina. The pulpit is to stand in the north-east angle of nave against the pier of chancel arch, being framed of oak and resting upon a solid granite base. The font is of granite, the bowl being supported upon four shafts, having a cover of oak with wrought-iron bands, and is to be placed at the west end of nave.

The cost of the church, fittings, and formation of the site, will be £1860, exclusive of architect's charges. It contains accommodation for 300 persons.

The works are being carried out from the designs and under the superintendence of Mr. J. P. St. Aubyn, of John-street, Bedford-row, London.

References to Plan.

A. Chancel.
B. Vestry.
C. South Aisle.
D. Nave.
E. Pulpit.
F. Font.
G. Porch.
H. Seating.
I. Children.

ROYAL SCOTTISH SOCIETY OF ARTS.

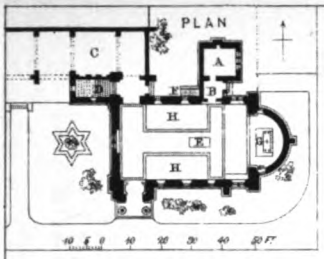
On an Improved Stove for Heating Apartments, Greenhouses, &c.
By James Stark, M.D., F.R.S.E.

The qualities which a good stove should possess are, that it should not be expensive in its original cost; that it should not be liable to get out of repair; that its heating power should be great as compared with the amount of fuel consumed; that it should occupy little space; that it should carry away freely the vitiated products of combustion; that the combustion of the fuel, and the heating power of the stove, should be under perfect command, and that the air of the apartment should not come into direct contact with the red-hot surface in which the fuel is being consumed, so that no burnt smell may be in the room.

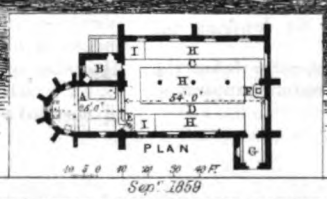
There may be many stoves which fulfil these conditions, but there is only one stove known to me, besides the one I am about to describe, which meets these requirements—I mean the water stove heated by gas, invented by Mr. W. Thomson, gardener to the Duke of Buccleuch. It is the most perfect stove with which I am acquainted; and, wherever gas can be commanded, can be strongly recommended. But the stove which I now recommend, if properly managed, I consider to be nearly equally perfect, while it possesses the additional advantage of being much less expensive in its original cost; while its annual expense for fuel would probably not amount to one-third of that of Mr. Thomson's; and the fuel not being gas, but the dross of any coal, is procurable everywhere.

Figs. 1 and 2 are diagrams of the stove which I have for the two past years had in constant use in my sitting-room. The body of the stove I, is a cylinder of common sheet iron, 8 inches in diameter, and is placed on the square cast-iron base of the common cockle stove of the Carron Iron Company. The door D is 5 inches in height by 6 inches in width, but the aperture is only 4½ inches in height, and is 7½ inches above the level of the bars B, on which the coal rests. The principal peculiarity, however, of the stove is, that all the space which is exposed to the action

Digitized by Google



St MARY AND St MICHAEL'S CHAPEL, CATHOLIC CEMETERY, KENSAL GREEN.
S.J. Nicholl, Archt



Sept 1859

NEW CHURCH MARAZION, CORNWALL
J.P. St Aubyn, Archt

J.R. Jobbins

Digitized by Google

Digitized by Google

of the heat is lined with a cast-iron cylinder C, about $\frac{3}{8}$ths of an inch in thickness. This cylinder of cast-iron rises nearly to the level of the top of the door, or about 11 inches above the level of the bars, but is cut away in front opposite the door, so as to admit of the coals being easily thrown in. The whole fire, then, is below the level of the open door, and confined entirely to the portion wholly lined with the cast-iron cylinder. As the cylinder

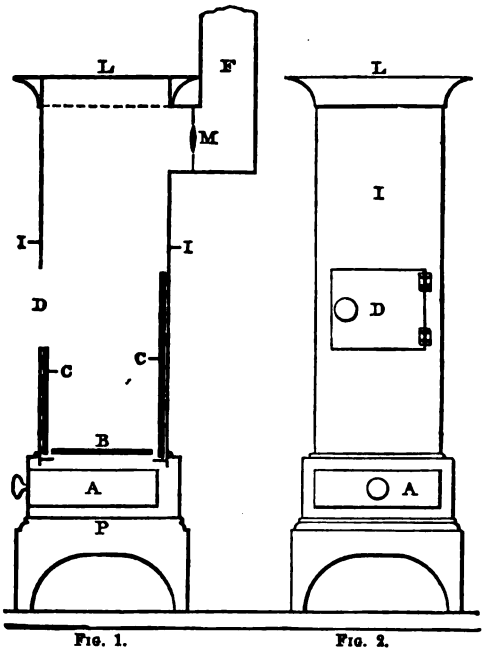


Fig. 1.

Fig. 2.

of sheet-iron I, fits easily over this cast-iron lining, a thin stratum of air is always interposed between the red-hot lining in which the coals and fire are contained, and the outer cylinder of sheet-iron which is in contact with the air of the apartment. The outer cylinder of sheet-iron thus never gets so over-heated as to *burn* the air; that is, it never scorches the particles of dust floating in the air, and thus no disagreeable burnt smell is ever perceptible in the apartment. From the thinness of the sheet-iron very little fuel is required to keep it at such a temperature that it rapidly heats the room; in fact, it is only in the coldest weather that it is necessary to raise the heat so high as to cause the water in the iron saucer on its flat top to become unpleasantly warm for the finger.

In the stove which I use, the height of the cylinder of sheet-iron from the moulding at the base to the moulding at the top is 22 inches. Seven inches of this space is below the door, and is close; the door occupies other 5 inches, and 8 inches of free space exists between the top of the door and the level from which the funnel for the smoke goes off, F; and the diameter of the smoke funnel is 4 inches, narrowing to $3\frac{1}{2}$, and it is furnished with a damper at M. The top of the stove is flat, and consists of a lid L, 10 inches in diameter, with $1\frac{1}{4}$ moulding. On this flat top is constantly kept a plate or saucer of tinned iron full of water, the evaporation from which keeps the air of the apartment in a wholesome and respirable state.

In order that the supply of air to the fuel may be completely under command, a sheet of iron P, is fixed across the bottom of the cast-iron base; and the ventilating apertures in front of the ash-pan A, are likewise covered over with sheet-iron. Air is therefore alone admitted to the base of the fire, by drawing out the ash-pan from an eighth of an inch to a whole inch. But as the whole comfort of a stove may be and too often is lost, from ignorance as to how to manage it, I purpose to append a few directions, the value of which I have repeatedly tested. These directions are of course intended in the first place for the stove now described, but are available for any stove, allowance being made for its peculiarity of construction. The size of the stove ought always to be accommodated to that of the apartment which requires to be heated. The stove just described heats a room 18 feet by 15 and $13\frac{1}{2}$ in height, and thus containing 3645 cubic feet of air. But allowing that bookcases and cabinets take up 600 feet, there are upwards of 3000 cubic feet of air to be heated by this small stove. When the temperature is from 40° to 45° outside, this stove is used as if it were a common grate, the coal dross being burned with the door wide open, and the damper allowing the air to escape the full width of the funnel. This mode of burning the fuel heats the room to from 63° to 65°; the fuel burns very slowly, and the temperature of the water on the top of the stove is about 80°. If the outside temperature ranges from 45° to 50° the door is still kept full open, but the ash-pan is shut quite close, so as to allow no air to pass through the fire, the whole supply of air to the coals comes from the open door. The coal therefore burns with extreme slowness, the water in the iron saucer on the top has a temperature of from 60° to 65°, and the air of the apartment 65°.

When the temperature ranges from 35° to 40°, as it does at the moment I am writing, with the door open, and the ash-pan drawn out half an inch, only shutting the door for about ten minutes each time fresh coal is thrown on, the temperature of the room at its remotest corner is 63°. When greater heat is required, as when the temperature is below 32°, the ash-pan is drawn open to the extent of *one-eighth* of an inch; the door is shut, and the damper left fully open. This often raises the temperature nearly to 70°, when the door is set open now and then whenever the heat threatens to become too great, or the damper may be turned so as to diminish draught through the exit-tube; but as it is the damper which is the fruitful cause of prejudice against stoves, and its mismanagement is the frequent cause of bad health among us, and of the destruction of flowers in conservatories, the rules which should direct its use merit a word of notice. Whenever stoves are used where there are children or large numbers of human beings, the access of air to the burning coal should be so managed that the damper never requires to be used at all. When a free current of air is passing through the coals, if the damper is turned so that the exit of foul air is retarded, it gathers at the top of the stove; and unless the cavity above the open of the door be large, as in the stove just described, a great portion of the noxious carbonic and sulphurous gases escape into the apartment. It is this which is often the cause of the bad health among children where stoves are used, because the persons using them do not understand their management; and I may add, that the faulty construction of almost all stoves is such that very few indeed can permit the door to be opened without allowing a large quantity of the noxious products of combustion to mix with the air. If the damper, then, is ever used at all, it is absolutely necessary to see that a greater quantity of air is not admitted to the coals than what can with ease escape through the narrowed aperture which the damper leaves. If this is not attended to, part of the noxious products of combustion will be thrown into the apartment; and neither man nor plant can breathe such gases with impunity. When, however, all the apertures are closed through which air may be admitted to the coals, the damper may be turned to a considerable extent; but always attending to the rule, that the apertures through which the gases escape should be able to carry away the full amount of air and gases which pass from the fire.

It was stated above that one of the peculiarities of the stove just described was its internal casing of cast-iron, the other peculiarity is the large cavity above the fireplace in which the noxious vapours may for a while remain without escaping into the room should anything temporarily obstruct their escape through the smoke-funnel. In the stove described, this space is 12 inches in height above the upper edge of the door, and when circumstances permit, it would be desirable even to increase the space. In all stoves not provided with a similar free space, a certain portion of the noxious products of combustion escape whenever the door is opened; but none escape when this point is attended to.

I cannot conclude this paper, however, without noticing one most important point relative to heating, which has been completely misunderstood; and, from being misunderstood, has been, and continues to be, the cause of the loss of hundreds of lives every winter.

You object to stoves because they *dry* the air. How is it they do this, allow me to ask? The answer is a very simple one,—viz. simply by raising the *temperature* of the air. It is from no inherent drying quality of the stove. The stove does not absorb one grain of moisture from the air; but by simply raising the temperature, it communicates a quality to the air called *a greater capacity for moisture;* and unless this demand for moisture is supplied in exact proportion to the degree of temperature gained, the air will become too dry for the healthy respiration of human beings and of plants. Nor is it of the smallest importance how

Digitized by Google

this increased temperature is given,—whether by an iron stove, by an open fireplace, or by steam or hot-water pipes,—the drying effect on the air is exactly the same, and exactly proportioned to the degree of temperature to which the air of the apartment is raised.

Now this is the reason why a saucer of metal containing water is recommended to be put on the top of the stove, and no stove or other means of heating ought ever to be admitted to any building where human beings are to meet, unless provision is made to render the air which they breathe sufficiently moist to meet the wants of the frame; and let it be constantly remembered, that the dryness of the air is not caused by the use of this or that stove, but that *every* means of heating produces the same effect, unless with the heat there be some means conjoined for the supply of watery vapour.

Stoves, however, have one disadvantage—they do not provide for the ventilation of the apartment in nearly so effectual a manner as open fireplaces; and as ventilation is as necessary for health as heat or moisture, this must be otherwise provided for wherever stoves is used. A sliding pane in the window, or the upper sash of the window fitted with ropes and pulleys, provides for the ventilation of the apartment more effectually than valves or openings of any kind into the chimney, which only remove the heated or vitiated air without furnishing a supply of fresh air. But it appears to me that by far the most effectual and safest mode of ventilating apartments in private dwelling-houses is to ventilate from the ceiling of the apartment—an aperture through the external wall communicating with the space between the ceiling of the room below, and the floor of the room above. This both allows of the escape of the heated and vitiated air, and of the entrance of cool and pure air; and as the air enters from above, the thorough ventilation of the room is secured. The ordinary stove valve, being fitted over the central ornament of the ceiling, permits of the regulation of the amount of ventilation according to the season, or to the number of persons in the apartment.

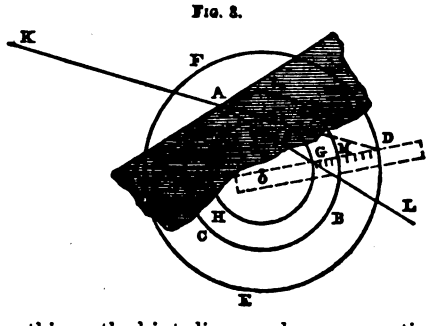
The medical value of stoves, more especially their superiority over open fireplaces in the treatment of diseases of the respiratory organs, must be reserved for some future occasion.

The annual cost of fuel for this stove, I calculate, has been for each year about one ton and a quarter of Scotch dross at 5*s.* a ton, including cartage, or about 6*s.* 6*d.* per annum.

Description and Drawing of a "Refraction Protractor," and of its application to the designing of the Prisms employed in Lighthouse Apparatus. By JAMES M. BALFOUR, C.E.

In all works on optics which I have seen, with one exception, the only method described of protracting the refraction of a ray of light at the surface of a medium is by laying off the sine of the angle of refraction in the constant ratio to that of the angle of incidence, which has been previously determined by observation.

FIG. 3.



As, however, this method is tedious, and as many optical problems may be solved with sufficient accuracy for practice by simple protraction, I was glad to find in one book a somewhat different method, which promised to be more easily available, although it is of course founded on the same principles. I refer to Dr. Young's 'Lecture on Natural Philosophy,' in the volume of plates accompanying which there is a drawing and a short description of a very elegant method of determining the position of a refracted ray. As this proposition is the foundation of all that follows, I shall briefly state it.

ABC (Fig. 3) is a circle touching the refracting surface at A,—if another circle DEF be drawn on the same centre, having its diameter to that of the first as the sine of the angle of incidence is to that of refraction, and a third circle GHI, which is less than the first in the same proportion as the second is greater; and if the direction of the incident ray KA be continued to D, and OD be drawn from the common centre O, cutting GHI in G, AG will be the direction of the refracted ray.*

On first reading this proposition I was struck by its novelty, and in consequence paid a considerable amount of attention to it, and it occurred to me that a great deal of time might be saved by drawing these proportional circles *once for all*, the method of doing which was at last simplified into employing an ordinary ruler properly graduated. This I have indicated in dotted lines on the figure, where OD is such a ruler, which may turn round a needle centre at the zero O. M, the point where the ruler cuts the circle ABC, is marked 1·0, D in the diagram is at 1·5, and the space MD may be divided into 5, or 50, or 500 equal parts, according to the degree of accuracy required; and of course the divisions may be carried as far beyond D as may be considered necessary. A decreasing scale is also carried inwards towards the centre from M, to correspond to the outer one, and numbered in a similar manner. Thus both the points D and G would be marked 1·5.

To use this instrument, all that is necessary is to draw a perpendicular to the surface of the medium, at the point of incidence of the ray whose path is to be traced, into the body of the refracting substance, and insert a needle or other centre at the distance OA=OM (or 1·0) from the surface. If we then turn round the ruler having its centre O superimposed on the needle till the division on the outer scale corresponding to the proper index of refraction (=1·5 in the figure) cuts the incident ray produced, and make a mark at the corresponding division on the inner scale, a line drawn from the point of incidence through the mark so made shows the direction of the ray through the medium.

This, I have said, is the simplest form of the instrument. It is applicable to tracing the direction of a ray of light through a medium whose position and index of refraction are given. It will also show the refractive index of a substance capable, when placed in a certain position, of refracting a given ray into a particular direction. When, however, we wish to ascertain the position of a surface with a known index of refraction which will have a certain effect on a given ray, some addition is necessary. The "refraction protractor" is then jointed at its zero-point to another ruler, in which there is a fine needle-hole at a distance from the joint=1 on the protractor, and this second ruler is fixed at the point of incidence by a needle passing through this hole.

The second ruler becomes a radius of the circle ABC, and its object is to enable us to alter the position of the centre O, still keeping it at the proper distance from the point of incidence A.

As an example, suppose we wished to find the position of the surface with an index of 1·5, which would refract the ray KA into the direction AL; all that is required is to fix the short ruler or radius by a needle at the point of contact A, and then to keep the division 1·5 on the outer scale moving along the incident ray produced until the division 1·5 on the inner scale intersects the line AL. A line perpendicular to the line joining the point A, and the centre of the joint at O, will then give the surface re-

---

* I am indebted to Mr. Swan for the following elegant solution of the proposition in the text:

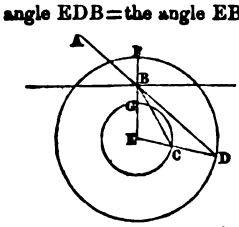
Let BE=a, and make EF = μa, and EG = $\frac{a}{\mu}$

If AB is an incident ray, BC the course of the refracted ray is found by producing AB to D, and joining DE and BC. For

$$DE \cdot EC = \mu a \times \frac{a}{\mu} = a^2 = BE^2$$

$$\therefore DE : BE :: BE : CE \quad (Euc.\ vi.\ 17);$$

hence (*Euc.* vi. 6) the angle EDB=the angle EBC.



Also $$\frac{\sin ABF}{\sin EBC} = \frac{\sin EBD}{\sin EDB} = \frac{ED}{EB} = \frac{\mu a}{a} = \mu.$$

Therefore BC is the course of the ray AB after refraction.

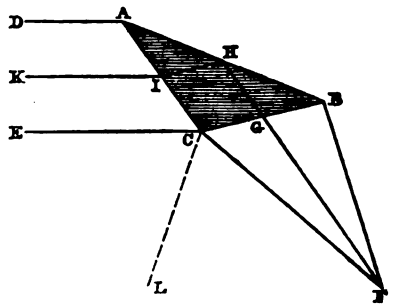
Digitized by Google

quired. The radius may be made with a piece at right angles to it, as shown in Fig. 5, where MN is the "refraction protractor," corresponding to OD in Fig. 3, MC is the radius, whose length =1 from M to C, where there is a fine needle-hole, and OCP is a ruler at right angles (by construction) to the radius MC. The centre line of OP gives at once the direction of the required surface.

This is the most useful form of the instrument. By combining two or more, the path of a ray of light through a refracting medium of any shape may be traced, or the form of a piece of glass determined, capable of producing any desired effect. Nor is the result a very rough one, as might be apprehended; on the contrary, even with a coarse instrument of box wood, I have succeeded in getting surprisingly accurate results, and I do not doubt that much greater accuracy might be attained with a more perfectly constructed instrument.

I shall now, as briefly as possible, describe the application of the "refraction protractor" to the determination of the forms of the totally reflecting prisms used in lighthouse apparatus. The diagram, Fig. 2, shows a section of one of these prisms for the purpose of explaining their properties, and the data from which they are constructed. The ray of light FB, coming from the

Fig. 4.

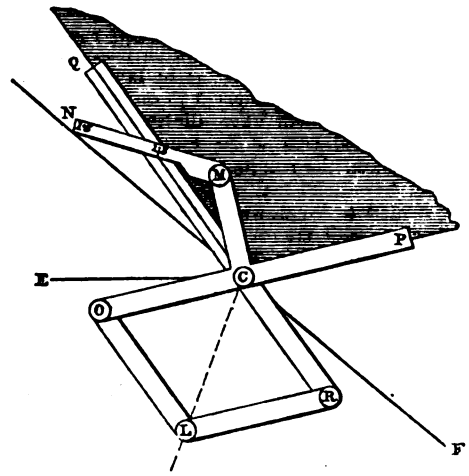


focus, is refracted, and then reflected at B, and passing directly along the lower face BC of the prism is again refracted into the horizontal direction CE. The ray FC in like manner is refracted at C, and passing directly up the face CA of the prism to A, is reflected and again refracted into the horizontal direction AD. Intermediate rays are of course acted on in a similar manner, as for instance the ray FGHIK. It will thus be perceived that, in order to keep the prisms as small as possible, the two extreme rays FB and FC trace the position of the sides CB and CA, and I may add that, as it is found convenient that the refractions caused by the two sides CA and CB shall be equal in amount, the angles BCE and FCA arising from these refractions must be equal, and consequently the angle FCB must equal the angle ECA. For ascertaining the form of the prism we have given the focus F, the position of the apex C of the triangle, a horizontal line, the length of one of the sides CA or CB, and the refractive index of the glass.

In practice, the directions of the sides CA and CB are first fixed; and though Mr. Alan Stevenson, in his various writings on lighthouse illumination, suggests that they might be determined by successive protractions, as they depend entirely on the refracted index of the glass, they have always hitherto been ascertained by a system of laborious calculation, and indeed the ordinary method of protraction would be little less laborious, as the whole process has to be repeated on each successive trial. In whatever way they were determined, however, it was entirely by a system of trial and error; and I may say that my reluctance to undergo such an ordeal was perhaps the main cause of my perfecting the refraction protractor, which I first designed upwards of five years ago.

If the description I have given of the protractor, and of the principles which regulate the form of the prisms, has been intelligible, it will be at once seen that the instrument offers great facilities in determining their figure. Thus we have only to fix the instrument I have already described, OPCMN, and another ruler QR, along with it at the point C of the prism (Fig. 5), so that they may turn freely on it as a centre, and keep them both moving together and constantly making equal angles with FC and CE respectively, while the extremity N of the protractor (it is cut off in this instrument at 1·5) is made to travel along the line FC produced until the division on the inner scale corresponding to 1·5 on the outer intersects the centre line of the ruler RQ. CP and CQ then show the exact positions of the two sides of the prism. The other rulers, OL and LR, are for the purpose of keeping the two, OP and RQ, always at equal angles

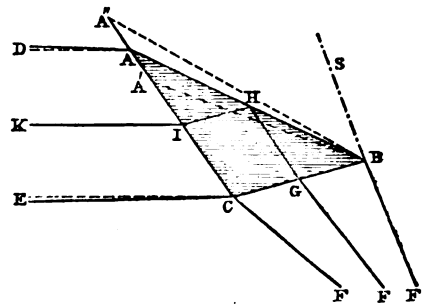
Fig. 5.



with the lines FC and CE, which they do as their point of connection at L is kept always on a line LC, bisecting the angle ECF; and as the lengths from joint to joint are all equal, they form a kind of equi-angular guide.

The refracting sides of the prism being thus fixed, it remains to determine the position of the reflecting side, whose accuracy is of the utmost consequence, as any error in its direction is doubled in the direction of the reflected ray. In the first place however, it is necessary to determine the length of one of the refracting sides, and we assume that it is the one next the radiant, as it somewhat simplifies the explanation. The lowest ray incident on the prism is refracted in the direction CA (Fig. 6), as we have

Fig. 6.



already seen, and in order to make it meet the refracting side AC at the proper angle, it must be reflected parallel to the side BC of the prism. This will be done, supposing the section of the prism to be bounded by straight lines, if we make CA'=CB. The highest ray, which is incident on the point B, is refracted into the direction BS, as may be ascertained by the refraction protractor. In order to reflect it in the proper direction, the reflecting side should be bounded by the line BA", which bisects the angle CBS.

Thus we have two directions BA and BA", for the reflecting side of the prism, and two lengths CA' and CA", for the anterior refracting side. If we now bisect the difference A'A" between these two lengths, and join BA, we get a third position for the reflecting side, which will operate with accuracy on the mean ray incident on the prism. If then the prism be made of the section shown by the triangle ABC, it will be amply accurate for practical purposes. Formerly indeed the reflecting side was ground to a curve to which the line BA" and a line drawn from A parallel to A'B were tangents, but they are now generally ground flat in the cross section, and the divergence caused by this theoretical error is kept within bounds by reducing the absolute size of the prism. When the side AC is first determined, the position of AB and the consequent length of BC, may be fixed by the instrument, but as the process is more complicated I shall not occupy time by describing it.

I may observe that the method of determining the form of the

Digitized by Google

prisms which I have just described may also be termed a system of trial and error, but it is so different from the methods formerly in use, that it would perhaps be more correct to call it a system of continuous trial, as the motion of the apparatus is continued till the error which is constantly visible is eliminated.

I shall now in conclusion, merely in a few words, mention the results obtained by the instrument which I have made.

On first constructing it I tested it by laying down full size a considerable number of the prisms at present in use in the Northern Lights apparatus, which have all been most carefully calculated to a very high degree of accuracy by Mr. Alan Stevenson. In every case I found the results to be quite within the allowable limits of error.

I then proceeded to lay down to a scale of double full size (to eliminate instrumental errors, &c.) a new series of smaller and more numerous prisms, which are now being introduced; and through nearly all of the prisms thus instrumentally determined I very carefully protracted by the ordinary method the path of the mean ray. This emerged in every case sensibly parallel to a horizontal line; thus proving the accuracy of the forms of the prisms.

With regard to the advantage to be derived from the use of the instrument, I may simply state that the whole set of twenty-four prisms were "laid down" in three or four days; and speaking of this, Mr. Alan Stevenson, who is so well acquainted with the laborious character of the work which the instrument was designed to avoid, says in a letter to me "In any case, I may say that your three or four days may safely be set against a month of computing."

I need only remind the reader of the irksome nature of the work which is avoided, in order to show the benefit derived from the use of the instrument, which, in the limited sphere to which it is adapted, may almost be said to supply the place of a calculating machine.

NOTES OF THE MONTH.

The London District Telegraph.—The report of Mr. Tyer, the engineer to this company, presented to the directors on the 23rd ult., states that the main trunk lines of the underground system are completed, connecting the central station in Threadneedle-street with Charing-cross, Westminster, Islington, and the London-road, near the Elephant and Castle. In carrying out the above sections great attention has been paid to render the work permanent, and recent improvements have been adopted, having especial reference to the preservation of the gutta-percha covering of the wires. The over-house system of pole telegraph completed comprises lines along the Waterloo-road, Kennington-road, New Kent-road, Walworth-road, and the Camberwell-road The length of telegraph completed is 9½ miles, of which 6 miles are underground, leaving 13 miles of telegraph in course of construction. A contract has been made by which the Surrey Canal Company have leased to this company the exclusive right for a term of years to erect poles and wires on the pathway of their canal. By this agreement much expense in the construction would be saved and many additional facilities afforded to the company. The directors have determined upon first opening the 11 district stations. The 89 sub-district stations would be taken as the works progressed, and it was expected that the whole of these would be ready for opening on the 1st of January next.

Science and Art Department.—Teachers wishing to attend the examinations of the Science and Art Department in—1. Practical and descriptive geometry, with mechanical and machine drawing, and building construction; 2. Physics; 3. Chemistry; 4. Geology and mineralogy (applied to mining); 5. Natural history,—for the purpose of obtaining augmentation grants to their salaries (under the Science Minute of the 2nd June 1859), must send their names, addresses, and present occupation, to the secretary of the department, South Kensington, on or before the 31st October 1859. The examinations will be held in the metropolis in the last week of November. Certificates of three grades will be granted in each subject, giving the holder an augmentation grant of £10, £15, or £20 a year on each certificate while giving instruction to a class of operatives in that subject. These payments will be in addition to the value of any certificates of competency for giving primary instruction, should the teacher have already obtained any such from the Committee of Council on Education.

British Association.—The arrangements for the meeting of the British Association in Aberdeen are nearly completed. The Association's meetings will be held in the new Music Hall. The proceedings will be commenced by H.R.H. the Prince Consort delivering the inaugural address on the evening of the 14th inst.

British Archæological Association.—The British Archæological Association will hold its annual meeting this year at Newbury, from the 12th inst. to the 17th inclusive. The Earl of Carnarvon is expected to preside.

Resistance to Shot of Iron and Steel Plates.—A series of experimental trials have been carried on during the past month at Portsmouth, with a view of ascertaining the amount of resistance offered by iron and steel plates of various manufactures when opposed to heavy ordnance at a short range. The trials had reference to the future coating of the steam ram now in progress of construction. The practice has been carried on from the Stork gunboat, tender to Her Majesty's ship Excellent, gunnery ship in Portsmouth harbour, both from a 32-pounder and a 95 cwt. gun, the latter throwing a solid 68 lb. shot, with 16 lb. charge of powder; the distance of range 200 yards. At this distance the results of the experiments have demonstrated that no iron or steel plate that has yet been manufactured can withstand the solid shot from the 95 cwt. gun at a short range. The first shot would not penetrate through the iron plate, but it would fracture it, and on three or four striking the plate in the same place, or in the immediate neighbourhood, it would be smashed to pieces. As the results of the trial affected the steel plates it proved that a steel-clothed ship could be far more easily destroyed than a wooden-sided one, and that on the smashing in of one of the steel plates the destruction of life on the armed ship's decks, supposing the broken plate to be driven through the ship's side, would be terrible, from the spread of the splintered material. At from 600 to 800 yards iron-clothed ships would be in comparative safety from the effects of an enemy's broadside, but the effects of concentrated firing have yet to be ascertained on the sides of an iron or steel clothed ship, and account also must be taken of the damage the woodwork forming the inner sides of such a ship would receive from the driving in of the broken plates, and which, as far as the present experiments have illustrated, would appear to prove that an iron or steel clad ship, on receiving a concentrated broadside from a frigate, armed in a similar manner to the Mersey, and struck near her waterline, must sink then and there, with her armour on her back.

Reading Room and Museum, Southampton.—A proposal made by the Town Council of Southampton, to expend £10,000 of the Hartley bequest in erecting a public reading-room and museum, has met the approval of the Vice Chancellor.

American Steam Fire-Engine.—The *Scientific American* states that one of the newly-constructed locomotive steam fire-engines lately ran 20 miles on a common road. The whole weight of the engine, water, and nine passengers was 12,000 lb., 9000 lb. being the weight of the engine alone. The first 3 miles were made in sixteen minutes running time, and it went over a bridge 350 feet long, with a draw of 40 feet in the centre, and up a very heavy grade, making 1000 feet in exactly one minute. The time occupied in travelling the 20 miles was two hours, grades and all included.

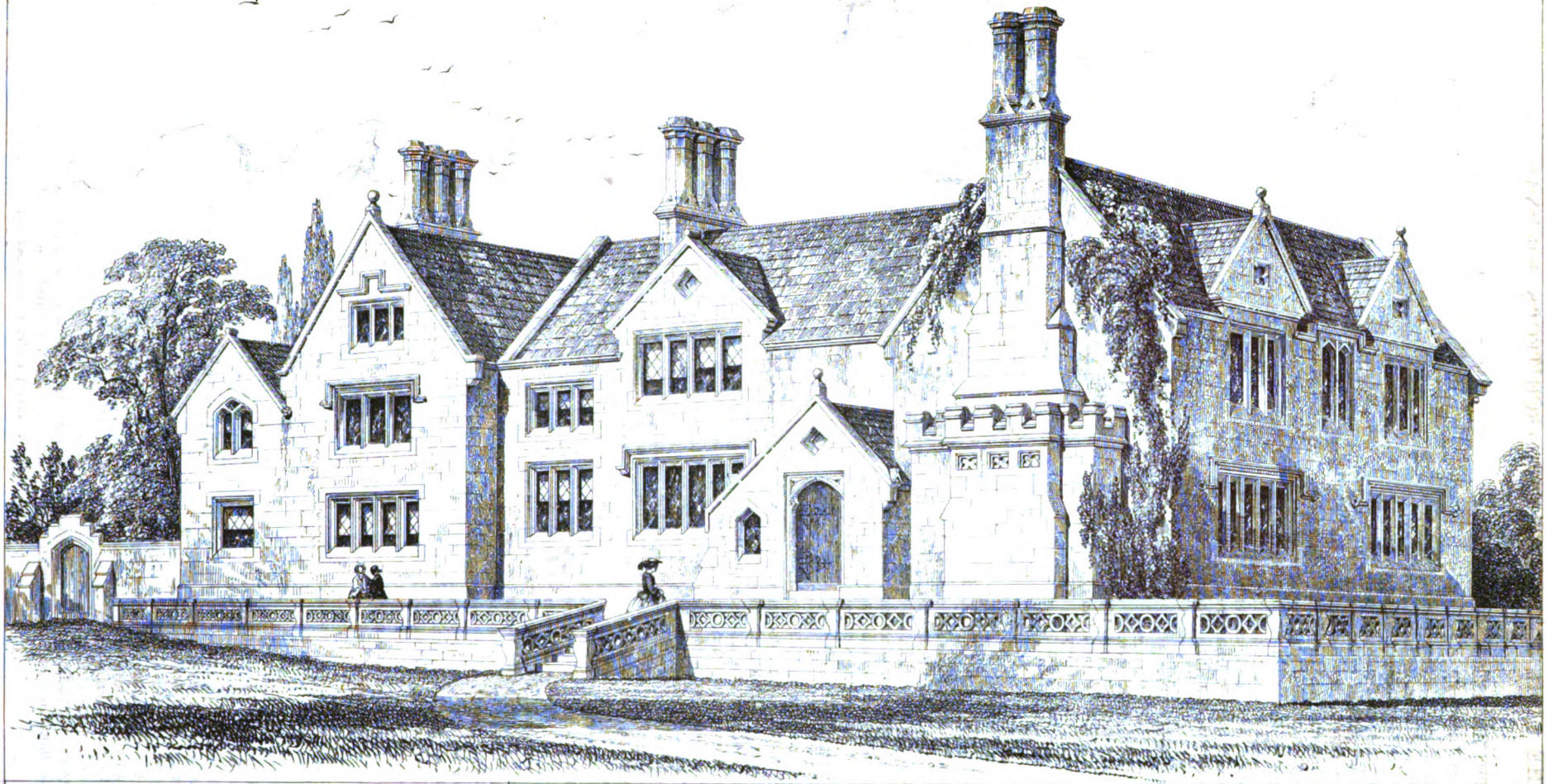
COMPETITIONS.

Designs are required for the erection of a new Guildhall and other public buildings at Cambridge. It is proposed to erect at present, at a cost not exceeding £6000, an assembly room, free library, and reading room, town clerk's offices, and rooms for the school of art, reserving the other portions of the design to a future occasion. Premiums, £200 and £100. The designs selected to be the property of the Council. The author of the selected design will not necessarily be employed as architect. The selection of the designs will be made by committee, consisting of inhabitants of the town, and members of the University, assisted by the opinion of non-competing architects. Particulars may be obtained at the Office of Mr. C. W. Cooper, Town Clerk, Guildhall, Cambridge. Designs (without the authors' names, but with a motto) to be sent in by the 31st October. A sealed letter, bearing the motto, and containing the author's name and address, to accompany each design.

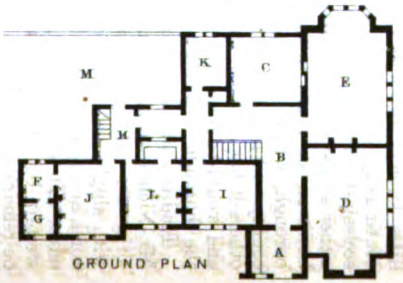
Designs are invited for a new Concert hall, to be erected in Belfast. Premiums £50 and £25. Particulars may be had on application to the secretary of the Ulster Hall Company, Belfast—(no date given).

Digitized by Google

Digitized by Google



DAWPOOL
HOUSE



GROUND PLAN

CHESHIRE

WALTER SCOTT, ARCHT

Oct^r 1859

J R Jobbins

Digitized by Google

DAWPOOL HOUSE, THURSTASTON, CHESHIRE.

(With an Engraving.)

The estate of Dawpool is beautifully situate on the east side of the river Dee, near its mouth, and takes its name from a pool or bay on its margin, formerly used by vessels trading to Ireland. The house was originally intended for a summer residence only, but was added to and otherwise enlarged to its present size, as a permanent residence. It is built with the red sandstone of the district, and nearly all the interior woodwork, including the panelling of the walls and ceiling of the dining-room, is of oak, richly carved and panelled. The style adopted, at the proprietor's request, is that of many of the halls and large farmhouses erected in Cheshire at the commencement of the 17th century, and of which nearly every village in this part of Cheshire contains one or more examples. The architect was Mr. Walter Scott, of Birkenhead and Liverpool.

References to Ground Plan.

A. Porch.
B. Hall.
C. Parlour.
D. Dining Room.
E. Drawing Room.
F. Store.
G. China Closet.
H. Passage.
I. Kitchen.
J. Servant's Hall.
K. Butler's Pantry.
L. Scullery.
M. Yard.

LOUGHBOROUGH CHURCH, LEICESTERSHIRE.

Leicestershire is a county whose churches are comparatively little known, although the district from its central position is continually traversed; but the truth is that, as a whole, the ecclesiastical structures do not present many attractive features either archæological or architectural. A notable exception must, however, be made in favour of the stately church at Loughborough, which is certainly among the best of those in the county which it has been our lot to examine. In common with others it has received the usual amount of destruction, neglect, and would-be revival, but it is now in contemplation to undertake the thorough repair and restoration internally and without.

Traditionally the church is dedicated to All Saints, though Mr. Nichols assigns it to St. Peter and St. Paul, but his authorities are not conclusive. It consists of a western tower, nave with single aisle on the north and double aisle on the south, north and south transepts, and chancel of the same width as the nave. There is a porch with a parvise over it in the extreme western bay on the south side—a very unusual situation, it may be remarked. The nave consists of four bays, though the outer south aisle, owing to the projections of the porch and transept, consists only of two. The main body of the church, including all the piers and arches, is of the fourteenth century, and its architecture may be defined as grand and severe, rather than ornamental. This is particularly observable within, where the bold and lofty piers, the still more lofty arches, with their curious and elaborate mouldings, are the features which give the grand character to the whole. There is one very great peculiarity, at variance with the general spirit of the mediæval period, viz., its almost uniform (it may be said) repetition of details. Throughout the building, every pier, every window, and almost every moulding, is the same, and withal sculpture and carving are scantily introduced, so that the grandeur of effect is marred, not by its simplicity, but its monotony. It is noticeable, too, that the chancel arch instead of springing, as usual, considerably above those of the nave, springs, in this instance, on the same level.

Up to about the middle of the fifteenth century, the church must have remained pretty much as it was originally built, with high-pitched roof throughout; but, in place of the present tower, there stood another, of which we have no traces, and so can only imagine its character from that of the early church. But this fifteenth century was the great age for *clerestories*,—seldom has an architectural fashion had so wide a run,—and the church in question shared the common lot. Then was its early character utterly destroyed, not merely by the addition of a clerestory to the nave, but by the low roof and parapets to the aisles and transepts,—the inserted windows in the chancel,—and the lower stage at least of the western tower, including the very fine west window, now shut out by the blockings and incumbrances of later times.

In 1747 the whole church was re-pewed. All the old woodwork of the benches, stalls, &c. was swept away, and the church reduced very nearly to the condition in which it now is. The brass eagle had long before been disposed of for £5. 2s. 10d., as we learn from one among the many curious entries in the church books.

The fabric is now in a condition that demands attention on more grounds than one, and it is proposed to undertake its thorough repair and refitting, towards the expenses of which a large sum has been already contributed. For the carrying out of the contemplated works, the services of Mr. G. G. Scott, of London, have been secured as superintending architect; and it is estimated that for substantial repairs from £4000 to £5000 will be required, and that for the fittings and other desirable improvements £2000 more.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Twenty-ninth Annual Meeting, held in Aberdeen, 1859.

OFFICERS.

President—His Royal Highness the Prince Consort.

Vice Presidents—The Duke of Richmond, K.G., F.R.S.; The Earl of Aberdeen, LL.D., F.R.S.; The Lord Provost of the City of Aberdeen; Sir John F. W. Herschel, Bart., D.C.L., M.A., F.R.S.; Sir David Brewster, LL.D., F.R.S.; Sir R. I. Murchison, D.C.L., F.R.S.; Rev. W. V. Harcourt, F.R.S.; Rev. T. R. Robinson, D.D., F.R.S.; A. Thomson, Esq., LL.D., F.R.S.

General Secretary—Major-General Edward Sabine, R.A., V.P.R.S.;—*Assistant General Secretary*—John Phillips, Esq., LL.D., F.R.S.;—*General Treasurer*—John Taylor, Esq., F.R.S.; *Local Secretaries for the Meeting in Aberdeen*—James Nicol, F.R.S.E., F.G.S.; Frederick Fuller, M.A.; John F. White. *Local Treasurers for the Meeting in Aberdeen*—John Angus; Newell Burnett.

The Twenty-ninth Annual Meeting of the British Association commenced its sittings at Aberdeen on the 14th of September, 1859. The First *General Meeting* was held, in the evening, at the Music-hall.

Prof. Owen, on rising to resign his Presidency to H.R.H. the Prince Consort, said,—Gentlemen of the British Association,—In rising to perform the brief concluding duty of my office, I may congratulate you on the present sound condition of the association, and am happy to say that I leave its affairs in a more prosperous state than I found them. Yet this prosperity has for some years been progressive, more especially as regards the direct scientific aims of the association. It was exemplified last year, by the presence of almost every surviving founder, with large additions of working scientific members, at our meeting at Leeds; it is cheeringly manifested by the present distinguished assemblage, including many of our most eminent continental and American fellow-labourers in science, whom the distance of our present place of meeting has not daunted in their desire to co-operate with us. This prosperous career of the association, I believe, is in some measure due to the element of common sense which mingles with our purely scientific aims. The founders and executive of the association have sought to harmonise its general course of action with the spirit of the social feelings and arrangements and constitution of Great Britain. Accordingly it has been the custom of the British Association for the Promotion of Science to select, in connection with its highest office, the names alternately of those who are habitually occupied in scientific labours, and of those who combine such pursuits, or an active interest in science, with high social rank and its attendant influence and duties. With pleasure we recall to mind, in the latter category of presidents, the Earl of Harrowby, the Marquess of Northampton, the Duke of Argyll; and now our election of this day is ratified by the presence of the highest personage nearest the sovereign of these realms. I need not before this assembly, representing as it does those classes who have always best appreciated it, dwell on the influence of his Royal Highness's co-operative labours, addresses, and example on every movement and organisation tending to advance the moral and intellectual condition of the people of Great Britain. Gentlemen, I thank you for the confidence you have reposed in me during the past year, and, with a grateful sense of the many advantages which I have derived therefrom, permit me to say, that not among the

Digitized by Google

least do I regard my present honourable relation in having, as my final duty, to resign my office and the present chair to H.R.H. the Prince Consort.

The Royal PRESIDENT then rose and said:—

The President's Address.

Gentlemen of the British Association,—Your kind invitation to me to undertake the office of president for the ensuing year could not but startle me on its first announcement. The high position which science occupies, the vast number of distinguished men who labour in her sacred cause, and whose achievements, while spreading innumerable benefits, justly attract the admiration of mankind, contrasted strongly in my mind with the consciousness of my own insignificance in this respect. I, a simple admirer and would-be student of science, to take the place of the chief and spokesman of the scientific men of the day, assembled in furtherance of their important objects!—the thing appeared to me impossible. Yet, on reflection, I came to the conclusion that, if not as a contributor to, or director of your labours, I might still be useful to you, useful to science, by accepting your offer. Remembering that this association is a popular association, not a secret confraternity of men jealously guarding the mysteries of their profession, but inviting the uninitiated, the public at large, to join them—having as one of its objects to break down those imaginary and hurtful barriers which exist between men of science and so-called men of practice—I felt that I could, from the peculiar position in which providence has placed me in this country, appear as the representative of that large public which profits by and admires your exertions, but is unable actively to join in them; that my election was an act of humility on your part, which to reject would have looked like false humility, that is, like pride, on mine. But I reflected further, and saw in mine acceptance the means, of which necessarily so few are offered to Her Majesty, of testifying to you, through the instrumentality of her husband, that your labours are not unappreciated by your sovereign, and that she wishes her people to know this as well as yourselves. Guided by these reflections, my choice was speedily made, for the path of duty lay straight before me.

If these, however, are the motives which have induced me to accept your flattering offer of the presidency, a request on my part is hardly necessary that you will receive my efforts to fulfil its duties with kind indulgence.

If it were possible for anything to make me still more aware how much I stand in need of this indulgence, it is the recollection of the person whom I have to succeed as your president—a man of whom this country is justly proud, and whose name stands among the foremost of the naturalists in Europe for his patience in investigation, conscientiousness in observation, boldness of imagination, and acuteness in reasoning. You have no doubt listened with pleasure to his parting address, and I beg to thank him for the flattering manner in which he has alluded to me in it.

The association meets for the first time to-day in these regions and in this ancient and interesting city. The poet, in his works of fiction, has to choose, and anxiously to weigh, where to lay his scene, knowing that, like the painter, he is thus laying in the background of his picture, which will give tone and colour to the whole. The stern and dry reality of life is governed by the same laws, and we are here living, feeling, and thinking under the influence of the local impressions of this northern seaport. The choice appears to me a good one. The travelling philosophers have had to come far, but in approaching the Highlands of Scotland they meet nature in its wild and primitive form, and nature is the object of their studies. The geologist will not find many novelties in yonder mountains, because he will stand there on the bare backbone of the globe, but the primary rocks, which stand out in their nakedness, exhibit the grandeur and beauty of their peculiar form, and in the splendid quarries of this neighbourhood are seen to peculiar advantage the closeness and hardness of their mass, and their inexhaustible supply for the use of man, made available by the application of new mechanical powers. On this primitive soil the botanist and zoologist will be attracted only by a limited range of plants and animals, but they are the very species which the extension of agriculture and increase of population are gradually driving out of many parts of the country. On those blue hills the red deer, in vast herds, hold undisturbed dominion over the wide heathery forest, until the sportsman, fatigued and unstrung by the busy life of the bustling town, invades the moor, to regain health and vigour by measuring his strength with that of the antlered monarch of the hill. But, notwithstanding all his efforts to overcome an antagonist possessed of such superiority of power, swiftness, caution, and keenness of all the senses, the sportsman would find himself baffled, had not science supplied him with the telescope and those terrible weapons which seem daily to progress in the precision with which they carry the deadly bullet, mocking distance, to the mark.

In return for the help which science has afforded him, the sportsman can supply the naturalist with many facts which he alone has opportunity of observing, and which may assist the solution of some interesting problems suggested by the life of the deer. Man also, the highest object of our study, is found in vigorous, healthy development, presenting a happy mixture of the Celt, Goth, Saxon, and Dane, acquiring his strength on the hills and the sea. The Aberdeen whaler braves the icy regions of the Polar Sea, to seek and to battle with the great monster of the deep: he has materially assisted in opening these icebound regions to the researches of science; he fearlessly aided in the search after Sir John Franklin and his gallant companions, whom their country sent forth on this mission, but to whom Providence, alas! has denied the reward of their labours, the return to their homes, to the affectionate embrace of their families and friends, and the acknowledgments of a grateful nation. The city of Aberdeen itself is rich in interest for the philosopher. Its two lately united Universities make it a seat of learning and science. The Collection of Antiquities, formed for the present occasion, enables him to dive into olden times, and, by contact with the remains of the handiworks of the ancient inhabitants of Scotland, to enter into the spirit of that peculiar and interesting people, which has always attracted the attention and touched the hearts of men accessible to the influence of heroic poetry. The Spalding Club, founded in this city for the preservation of the historical and literary remains of the north-eastern counties of Scotland, is honourably known by its important publications.

Gentlemen, this is the twenty-ninth anniversary of the foundation of this association, and well may we look back with satisfaction to its operations and achievements throughout the time of its existence. When, on the 27th September 1831, the meeting of the Yorkshire Philosophical Society took place at York in the theatre of the Yorkshire Museum, under the presidency of the late Earl Fitzwilliam, then Viscount Milton, and the Rev. W. Vernon Harcourt eloquently set forth the plan for the formation of a British Association for the promotion of science, which he showed to have become a want for this country, the most ardent supporter of this association could not have anticipated that it would start into life full grown, as it were, enter at once upon its career of usefulness, and pursue it without deviating from the original design, triumphing over the oppositions which it had to encounter in common with everything that is new and claims to be useful. Gentlemen, this proved that the want was a real and not an imaginary one, and that the mode in which it was intended to supply that want was based upon a just appreciation of unalterable truths. Mr. Vernon Harcourt summed up the desiderata in graphic words, which have almost identically been retained as the exposition of the objects of the society, printed at the head of the annually appearing volume of its *Transactions*,—To give a stronger impulse and more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the empire with one another and with foreign philosophers; and to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress.

To define the nature of science, to give an exact and complete definition of what that science, to whose service the association is devoted, is and means, naturally must at all times occupy the metaphysician. He has answered the question in various ways, more or less satisfactory to himself or others. To me science in its most general and comprehensive acceptation means the knowledge of what I know, the consciousness of human knowledge. Hence to know is the object of all science, and all special knowledge, if brought to our consciousness in its separate distinctiveness from, and yet in its recognised relation to, the totality of our knowledge, is scientific knowledge. We require then for science—that is to say, for the acquisition of scientific knowledge—those two activities of our mind which are necessary for the acquisition of any knowledge, analysis and synthesis: the first to dissect and reduce into its component parts the object to be investigated, and to render an accurate account to ourselves of the nature and qualities of these parts by observation; the second to recompose the observed and understood parts into a unity in our

Digitized by Google

consciousness, exactly answering to the object of our investigation. The labours of the man of science are therefore at once the most humble and the loftiest which man can undertake. He only does what every little child does from its first awakening into life—and must do every moment of its existence—and yet he aims at the gradual approximation to Divine truth itself. If then there exists no difference between the work of the man of science and that of the merest child, what constitutes the distinction? Merely the conscious self-determination. The child observes what accident brings before it, and unconsciously forms its notion of it. The so-called practical man observes what his special work forces upon him, and he forms his notions upon it with reference to this particular work. The man of science observes what he intends to observe, and knows why he intends it. The value which this peculiar object has in his eyes is not determined by accident, nor by an external cause, such as the mere connection with work to be performed—but by the place which he knows this object to hold in the general universe of knowledge,—by the relation which it bears to other parts of that general knowledge. To arrange and classify that universe of knowledge becomes therefore the first and perhaps the most important object and duty of science. It is only when brought into a system, by separating the incongruous and combining those elements in which we have been enabled to discover the internal connection which the Almighty has implanted in them, that we can hope to grapple with the boundlessness of His creation, and with the laws which govern both mind and matter.

The operation of science, then, has been systematically to divide human knowledge, and raise as it were the separate grounds of subjects for scientific consideration into different and distinct sciences. The tendency to create new sciences is peculiarly apparent in our present age, and is perhaps inseparable from so rapid a progress as we have seen in our days. For the acquaintance with and mastering of distinct branches of knowledge enables the eye, from the newly-gained points of sight, to see the new ramifications into which they divide themselves, in strict consecutiveness, and with logical necessity. But in thus gaining new centres of light from which to direct our researches, and new and powerful means of adding to its ever-increasing treasures, science approaches no nearer to the limits of its range, although travelling further and further from its original point of departure. For God's world is infinite, and the boundlessness of the universe whose confines appear ever to retreat before our finite minds, strikes us no less with awe when, prying into the starry crowd of heaven, we find new worlds revealed to us by every increase in the power of the telescope, than when the microscope discloses to us in a drop of water or an atom of dust new worlds of life and animation, or the remains of such as have passed away.

Whilst the tendency to push systematic investigation in every direction enables the individual mind of man to bring all the power of which he is capable to bear on the specialities of his study, and enables a greater number of labourers to take part in the universal work, it may be feared that that consciousness of its unity which must pervade the whole of science, if it is not to lose its last and highest point of sight, may suffer. It has occasionally been given to rare intellects and the highest genius to follow the various sciences in their divergent roads, and yet to preserve that point of sight from which alone their totality can be contemplated and directed. Yet how rare is the appearance of such gifted intellects! and if they be found at intervals, they remain still single individuals, with all the imperfections of human nature.

The only mode of supplying with any certainty this want, is to be sought in the combination of men of science, representing all the specialities, and working together for the common object of preserving that unity, and presiding over that general direction. This has been to some extent done in many countries by the establishment of academies embracing the whole range of the sciences, whether physical or metaphysical, historical or political. In the absence of such an institution in this country, all lovers of science must rejoice at the existence and activity of this association, which embraces in its sphere of action, if not the whole range of the sciences, yet a very large and important section of them—those known as the inductive sciences, excluding all that are not approached by the inductive method of investigation.

It has, for instance (and, considering its peculiar organisation and mode of action, perhaps not unwisely), eliminated from its consideration and discussions those which come under the description of moral and political sciences. This has not been done from undervaluing their importance and denying their sacred right to the special attention of mankind, but from a desire to deal with those subjects only which can be reduced to positive proof, and do not rest on opinion or faith. The subjects of the moral and political sciences involve not only opinions but feelings; and their discussion frequently rouses passions. For feelings are "subjective," as the German metaphysician has it—they are inseparable from the individual being—an attack upon them is felt as one upon the person itself; while facts are "objective" and belong to everybody—they remain the same facts at all times and under all circumstances: they can be proved; they have to be proved, and when proved, are finally settled. It is with facts only that the association deals. There may for a time exist differences of opinion on these also, but the process of removing them and resolving them into agreement is a different one from that in the moral and political sciences. These are generally approached by the *deductive* process; but if the reasoning be ever so acute and logically correct, and the point of departure, which may be arbitrarily selected, is disputed, no agreement is possible: whilst we proceed here by the *inductive* process, taking nothing on trust, nothing for granted, but reasoning upwards from the meanest fact established, and making every step sure before going one beyond it, like the engineer in his approaches to a fortress. We thus gain ultimately a roadway, a ladder by which even a child may, almost without knowing it, ascend to the summit of truth, and obtain that immensely wide and extensive view which is spread below the feet of the astonished beholder. This road has been shown us by the great Bacon; and who can contemplate the prospects which it opens, without almost falling into a trance similar to that in which he allowed his imagination to wander over future ages of discovery!

From amongst the political sciences it has been attempted in modern times to detach one which admits of being severed from individual political opinions, and of being reduced to abstract laws derived from well authenticated facts. I mean Political Economy, based on general statistics.

A new association has lately been formed, imitating our perambulating habits, and striving to comprehend in its investigations and discussions even a still more extended range of subjects in what is called "social science." These efforts deserve our warmest approbation and goodwill. Our own association has since its meeting at Dublin recognised the growing claims of political economy to scientific brotherhood, and admitted it into its statistical section. It could not have done so under abler guidance and happier auspices than the presidency of the Archbishop of Dublin, Dr. Whately, whose efforts in this direction are so universally appreciated. But even in this section, and whilst statistics alone were treated in it, the association as far back as 1833 made it a rule, that in order to insure positive results only those classes of facts should be admitted which were capable of being expressed by numbers, and which promised when sufficiently multiplied to indicate general laws. If then the main object of science—and I beg to be understood henceforth as speaking only of that section which the association has under its special care, viz., inductive science—if, I say, the object of science is the discovery of the laws which govern natural phenomena, the primary condition for its success is accurate observation and collection of facts in such comprehensiveness and completeness as to furnish the philosopher with the necessary material from which to draw safe conclusions.

Science is not of yesterday. We stand on the shoulders of past ages, and the amount of observations made, and facts ascertained, has been transmitted to us and carefully preserved in the various storehouses of science; other crops have been reaped, but still lie scattered on the field; many a rich harvest is ripe for cutting, but waits for the reaper. Economy of labour is the essence of good husbandry, and no less so in the field of science. Our association has felt the importance of this truth, and may well claim as one of its principal merits the constant endeavour to secure that economy.

One of the latest undertakings of the association has been, in conjunction with the Royal Society, to attempt the compilation of a classified catalogue of scientific memoirs, which, by combining under one head the titles of all memoirs written on a certain subject, will, when completed, enable the student who wishes to gain information on that subject to do so with the greatest ease. It gives him, as it were, the plan of the house, and the key to the different apartments in which the treasures relating to his subject are stored, saving him at once a painful and laborious search,

Digitized by Google

and affording him at the same time an assurance that what is here offered contains the whole of the treasures yet acquired.

While this has been one of its latest attempts, the association has from its very beginning kept in view that its main sphere of usefulness lay in that concentrated attention to all scientific operations which a general gives to the movements of his army, watching and regulating the progress of his impetuous soldiers in the different directions to which their ardour may have led them, carefully noting the gaps which may arise from their independent and eccentric action, and attentively observing what impediments may have stopped, or may threaten to stop, the progress of certain columns.

Thus it attempts to fix and record the position and progress of the different labours, by its reports on the state of sciences published annually in its *Transactions;*—thus it directs the attention of the labourers to those gaps which require to be filled up, if the progress is to be a safe and steady one;—thus it comes forward with a helping hand in striving to remove those impediments which the unaided efforts of the individual labourer have been or may be unable to overcome.

Let us follow the activity of the association in these three different directions.

The reports on the state of science originate in the conviction of the necessity for fixing, at given intervals, with accuracy and completeness, the position at which it has arrived. For this object the General Committee of the association entrusts to distinguished individuals in the different branches of science the charge of becoming, as it were, the biographers of the period. There are special points in different sciences in which it sometimes appears desirable to the different sections to have special reports elaborated; in such cases the General Committee, in its capacity of the representative assembly of all the sciences, reserves to itself the right of judging what may be of sufficient importance to be thus recorded.

The special subjects which the association points out for investigation, in order to supply the gaps which it may have observed, are—either such as the philosopher alone can successfully investigate, because they require the close attention of a practised observer, and a thorough knowledge of the particular subject; or they are such as require the greatest possible number of facts to be obtained. Here science often stands in need of the assistance of the general public, and gratefully accepts any contributions offered, provided the facts be accurately observed. In either case the association points out *what* is to be observed, and *how* it is to be observed.

The first is the result of the same careful sifting process which the association employs in directing the issue of special reports. The investigations are entrusted to specially-appointed committees, or selected individuals. They are in most cases not unattended with considerable expense, and the association, not content with merely suggesting and directing, furnishes by special grants the pecuniary means for defraying the outlay caused by the nature and extent of the inquiry. If we consider that the income of the association is solely derived from the contributions of its members, the fact that no less a sum than £17,000 has since its commencement been thus granted for scientific purposes is certainly most gratifying.

The question *how* to observe, resolves itself into two—that of the scientific method which is to be employed in approaching a problem or in making an observation, and that of the philosophical instruments used in the observation or experiment. The association brings to bear the combined knowledge and experience of the scientific men not only of this but of other countries, on the discovery of that method which, while it economises time and labour, promises the most accurate results. The method to which after careful examination the palm has been awarded, is then placed at the free disposal and use of all scientific investigators. The association also issues, where practicable, printed forms, merely requiring the different heads to be filled up, which by their uniformity become an important means for assisting the subsequent reduction of the observations for the abstraction of the laws which they may indicate.

At the same time most searching tests and inquiries are constantly carried on in the observatory at Kew, given to the association by Her Majesty, the object of which is practically to test the relative value of different methods and instruments, and to guide the constantly progressive improvements in the construction of the latter. The establishment at Kew has undertaken the further important service of verifying and correcting to a fixed standard the instruments of any maker, to enable observations made with them to be reduced to the same numerical expression. I need hardly remind the inhabitants of Aberdeen that the association, in one of the first years of its existence, undertook the comparative measurement of the Aberdeen standard scale with that of Greenwich,—a research ably carried out by the late Mr. Baily.

The impediments to the general progress of science, the removal of which I have indicated as one of the tasks which the association has set for itself, are of various kinds. If they were only such as direction, advice, and encouragement would enable the individual or even combined efforts of philosophers to overcome, the exertions of the association which I have just alluded to might be sufficient for the purpose. But they are often such as can only be successfully dealt with by the powerful arm of the state or the long purse of the nation. These impediments may be caused either by the social condition of the country itself, by restrictions arising out of peculiar laws, by the political separation of different countries, or by the magnitude of the undertakings being out of all proportion to the means and power of single individuals, of the association, or even the voluntary efforts of the public. In these cases the association, together with its sister society, the Royal Society, becomes the spokesman of science with the crown, the government, or parliament—sometimes even, through the home government, with foreign governments. Thus it obtained the establishment by the British government of magnetic and meteorological observatories in six different parts of the globe, as the beginning of a network of stations which we must hope will be so far extended as to compass by their geographical distribution the whole of the phenomena which throw light on this important point in our tellurian and even cosmical existence. The Institute of France, at the recommendation of M. Arago, whose loss the scientific world must long deplore, cheerfully co-operated with our council on this occasion. It was our association which, in conjunction with the Royal Society, suggested the Antarctic Expedition, with a view to further the discovery of the laws of terrestrial magnetism, and thus led to the discovery of the southern polar continent. It urged on the Admiralty the prosecution of the tidal observations, which that department has since fully carried out. It recommended the establishment, in the British Museum, of the conchological collection exhibiting present and extinct species, which has now become an object of the greatest interest.

I will not weary you by further examples, with which most of you are better acquainted than I am myself, but merely express my satisfaction that there should exist bodies of men who will bring the well-considered and understood wants of science before the public and the government, who will even hand round the begging-box, and expose themselves to refusals and rebuffs to which all beggars are liable, with the certainty, besides, of being considered great bores. Please to recollect that this species of bore is a most useful animal, well adapted for the ends for which nature intended him. He alone, by constantly returning to the charge, and repeating the same truths and the same requests, succeeds in awakening attention to the cause which he advocates, and obtains that hearing which is granted him at last for self-protection, as the minor evil compared to his importunity, but which is requisite to make his cause understood. This is more particularly the case in a free, active, enterprising, and self-determining people like ours, where every interest works for itself, considers itself the all-important one, and makes its way in the world by its own efforts. Is it then to be wondered at, that the interests of science, abstract as science appears, and not immediately showing a return in pounds, shillings, and pence, should be postponed, at least, to others which promise immediate tangible results? Is it to be wondered at, that even our public men require an effort to wean themselves from other subjects in order to give their attention to science and men of science, when it is remembered that science, with the exception of mathematics, was until of late almost systematically excluded from our school and university education;—that the traditions of early life are those which make and leave the strongest impression on the human mind, and that the subjects with which we become acquainted, and to which our energies are devoted in youth, are those for which we retain the liveliest interest in after years, and that for these reasons the effort required must be both a mental and a moral one? A deep debt of gratitude is therefore due to bodies like this association, which not only urges the wants of science on the government, but furnishes it at once with well-

Digitized by Google

matured plans how to supply them with the greatest certainty and to the greatest public advantage.

We may be justified in hoping, however, that by the gradual diffusion of science, and its increasing recognition as a principal part of our national education, the public in general, no less than the legislature and the state, will more and more recognise the claims of science to their attention; so that it may no longer require the begging-box, but speak to the state, like a favoured child to its parent, sure of his parental solicitude for its welfare; that the state will recognise in science one of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand.

If the activity of this association, such as I have endeavoured to describe it, ever found or could find its personification in one individual—its incarnation, as it were—this had been found in that distinguished and revered philosopher who has been removed from amongst us in his ninetieth year, within these last few months. Alexander von Humboldt incessantly strove after dominion over that universality of human knowledge which stands in need of thoughtful government and direction to preserve its integrity; he strove to tie up the *fasces* of scientific knowledge, to give them strength in unity. He treated all scientific men as members of one family, enthusiastically directing, fostering, and encouraging inquiry, where he saw either the want of, or the willingness for it. His protection of the young and ardent student led many to success in their pursuit. His personal influence with the courts and governments of most countries in Europe enabled him to plead the cause of science in a manner which made it more difficult for them to refuse than to grant what he requested. All lovers of science deeply mourn for the loss of such a man. Gentlemen, it is a singular coincidence, that this very day on which we are here assembled, and are thus giving expression to our admiration of him, should be the anniversary of his birth.

To return to ourselves, however: one part of the functions of the association can receive no personal representation, no incarnation: I mean the very fact of meetings like that which we are at present inaugurating. This is not the thoughtful direction of one mind over acquired knowledge, but the production of new thought by the contact of many minds, as the spark is produced by the friction of flint and steel; it is not the action of the monarchy of a paternal government, but the republican activity of the Roman Forum. These meetings draw forth the philosopher from the hidden recesses of his study, call in the wanderer over the field of science to meet his brethren, to lay before them the results of his labours, to set forth the deductions at which he has arrived, to ask for their examination, to maintain in the combat of debate the truth of his positions and the accuracy of his observations. These meetings, unlike those of any other society, throw open the arena to the cultivators of all sciences, to their mutual advantage: the geologist learns from the chemist that there are problems for which he had no clue, but which that science can solve for him; the geographer receives light from the naturalist, the astronomer from the physicist and engineer, and so on. And all find a field upon which to meet the public at large, invite them to listen to their reports and even to take part in their discussions,—show to them that philosophers are not vain theorists, but essentially men of practice—not conceited pedants, wrapped up in their own mysterious importance, but humble inquirers after truth, proud only of what they may have achieved or won for the general use of man. Neither are they daring and presumptuous unbelievers—a character which ignorance has sometimes affixed to them—who would, like the Titans, storm heaven by placing mountain upon mountain, till hurled down from the height attained by the terrible thunders of outraged Jove; but rather the pious pilgrims to the Holy Land, who toil on in search of the sacred shrine, in search of truth—God's truth—God's laws as manifested in His works, in His creation.

Proceedings of Sections.

Condensed Abstract of a first set of Experiments, by Messrs. Robert Napier and Sons, on the strength of Wrought-iron and Steel.

Communicated by W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

The experiments to which this abstract relates form the first set of a long series now in progress by Messrs. Robert Napier and Sons; the details being conducted by their assistant, Mr. Kirkcaldy. The whole results are now in the course of being printed *in extenso* for publication in the Transactions of the Institution of Engineers in Scotland; but some time must elapse before they can appear, owing to the great volume of the tables and the number of particulars which they give.

The present abstract is all that it has been found practicable to prepare in time for the meeting of the British Association; and notwithstanding its brevity and extreme condensation, it is believed that the results which it shows will be found of interest and importance. It gives the tenacity, and the ultimate extension when on the point of being torn asunder, of the *strongest* and the *weakest* kinds of iron and steel from each of the districts mentioned. Each result is the mean of four experiments at least, and sometimes of many more. The detailed tables, now being printed, will show many more particulars; and especially the contraction of the bars in transverse area along their length generally, owing to "drawing out," and the still greater contraction at the point of fracture. The experiments now complete were all made with loads applied gradually. Experiments on the effect of suddenly applied loads are in progress.

	Tenacity in lbs. per square inch.	Ultimate extension in decimals of length.
Table A. *Iron Bars.*		
Yorkshire, strongest	62886	0·256
,, weakest	60075	0·205
,, (forged)	66392	0·202
Staffordshire, strongest	62231	0·222
,, weakest	56715	0·225
West of Scotland, strongest	64795	0·173
,, weakest	56655	0·191
Sweden, strongest	48232	0·264
,, weakest	47855	0·278
Russia, strongest	56805	0·153
,, weakest	49564	0·133
Table B. *Iron Plates.*		
Yorkshire, strongest lengthwise	56005	0·141
,, weakest ,,	52000	0·132
,, strongest crosswise	50515	0·093
,, weakest ,,	46221	0·076
Table C. *Steel Bars.*		
Steel for tools, rivets, &c., strongest	132909	0·054
,, ,, weakest	101151	0·108
,, for other purposes, strongest	92015	0·153
,, ,, weakest	71486	...
Table D. *Steel Plates.*		
Strongest lengthwise	94289	0·0571
Weakest ,,	75594	0·1982
Strongest crosswise	96308	0·0964
Weakest ,,	69082	0·1964

Note.—The strongest lengthwise is the weakest crosswise, and *vice versa*.

Note.—The strongest and weakest lengthwise are also respectively the strongest and weakest crosswise.

Submergence of Telegraph Cables. By Homersham Cox, M.A.

The mechanical theory of the submergence of telegraphic cables has been the subject of much discussion and of numerous mathematical investigations. They are based on assumptions from which the following principal results are established with respect to cables paid out uniformly in still water, and not subject to tension at the bed of the sea.

1. The descending cable is in a straight line, so inclined that its weight and the fluid resistance are in equilibrium.

2. The tension of this cable at any point is nearly equal to the weight of a length of similar cable equal to the vertical depth below that point.

These two propositions have been the subjects of several demonstrations more or less rigorous, but all of them very complicated. The first object of this paper is to demonstrate them very simply.

The hypotheses on which the propositions just stated depend are, that the paying-out vessel moves uniformly and rectilinearly, and that the cable is paid out at a greater velocity than that of the ship. It follows that, if the bed of the sea be horizontal, the cable will not lie *taut* upon it, and therefore neglecting as inconsiderable the friction of the bed of the sea, it is seen that the cable must have no tension at its lowest point. The case would be entirely altered if there were such inequalities of the bed of the sea that the cable on it sustained tension; as it would when

Digitized by Google

suspended across chasms or resting on inclined planes steeper than the "limiting" angle corresponding to the coefficient of friction of the cable on them.

It is also assumed that the descending cable has no oscillatory movement, but preserves always the same form as it travels forward.

Now what are the forces acting on this portion of the cable? Obviously these—gravity, the normal fluid resistance, and the tangential fluid resistance. Something has to be said of each of these forces. In the first place the weight of the cable to be considered is its weight in water, or its weight in vacuo minus the weight of the fluid displaced. Secondly, the normal fluid resistance is ordinarily assumed to vary as the square of the relative normal velocity with which the cable meets the water. This law is not however strictly accurate, for it is found that a solid which moves through water at various angles of inclination to the direction of motion, does not meet with resistances which vary as the square of the sine of that angle ('Encyclopedia Britannica,' art. Hydrodynamics). This, however, is certain, that if different parts of the cable be differently inclined, those which are more nearly vertical being more directly opposed to the fluid, suffer greater resistance than those parts which move more obliquely through it.

The third force, the tangential friction of the fluid is extremely small, as will be hereafter shown, and may usually be neglected.

Now to find in the first place the form of the line of the descending cable: we observe that this line progresses with a constant horizontal velocity equal that of the ship, but this horizontal velocity, except in so far as it causes the resistance of the fluid, does not affect the form of the cable. It is a consequence of D'Alembert's principle that this constant horizontal velocity may be abstracted. The velocity of paying out must, however, be taken into account, for if the parts of the cable moved in a curve, they would be subject to centrifugal forces due to this velocity.

It can be seen at once that the rectilineal form is at least a possible form of the descending cable, if it descend so obliquely that the normal fluid resistances balance the effect of gravity. In such case the motion of every part would be rectilineal; the centrifugal force would not exist, and the whole might be regarded as in a state of statical equilibrium. But we have to show that this rectilinear form is the only possible form of the cable under the assumed circumstances.

Let s be the length from the bed of the sea to any point of the curve, δs an element of its length, T and T+δT the tensions at its extremities, Rδs the normal resistance on the element, Mδs its mass, M$g\delta s$ its weight in water, θ the angle at which the curve is inclined to the horizon, n the velocity of paying out. Then resolving forces normally, we easily find

$$(Mn^2-T)\frac{d\theta}{ds}=R-Mg\cos\theta.$$

This is a differential equation to the curve when the values of T and R are substituted in it. In the case before us the equation represents a straight line only, as may be shown as follows. The velocity of paying out is small, and is equal to that which would be produced by gravity on a body descending freely through a very small distance. Therefore Mn^2 is equal to the weight of a small piece of the cable (never more than a foot or two). T is zero at the bed of the sea and very great at its surface. There is therefore an intermediate point near the bed, where $T=Mn^2$. Call this point A. As the first side of the equation is zero for that point, the second side must be so also.

Now in the first place, if the curve above A be concave upwards, θ increases above A and $\frac{d\theta}{ds}$ is positive. T also increases above A. Therefore for points above A the first side of the equation is negative. At the same time R increases, because we have assumed that the more upright the curve is the greater is the resistance. Also $\cos\theta$ has diminished; or the second side of the equation is positive. The supposition of the curve above A being concave upwards thus leads to an absurdity.

In the same way it may be shown that the curve is not concave downwards, and the demonstration may be extended to the part of the cable below A.

It follows that $\frac{d\theta}{ds}$ is everywhere 0 and $R=Mg\cos\theta$. In other words the descending cable is in a straight line, such that the normal fluid resistance is equal to to the weight resolved normally.

It is an immediate consequence that if the friction of the water be neglected the tension is equal to the weight of a portion of the chain equal in length to the depth of the sea. For the tension is the same as if the cable were at rest on a smooth inclined plane, and therefore follows the law just mentioned.

The law of tension just mentioned is not however a mere consequence of the cable hanging in a straight line. The law may be proved by resolving the forces tangentially without assuming the line to be straight; and this method of tangential resolution has the advantage of giving the law when the cable does hang in curve, as it does when subject to tension at the bed of the sea.

It may be observed that the differential equation for the form of the chain here given, accords with the equations for the vertical and horizontal motion of the cable given by Prof. Airy in the 'Philosophical Magazine,' No. 104, where, however, they are left unsolved. It may be added, that the conclusions of this paper vary from those of the paper cited, on account of the different estimate here adopted of the value of the coefficient of fluid friction. Prof. Airy states in his paper that he has no data for determining that coefficient. It has been determined however by a very careful experimenter, Col. Beaufoy, whose collection of "Nautical and Hydraulic Experiments" has great reputation. The conjectural value of the coefficient adopted by Prof. Airy appears to be much too large.

According to the theory above considered, the Atlantic cable at the actual velocities descended in the form of a straight line inclined between 10 and 20 degrees to the horizon, and the fluid friction acting tangentially on the Atlantic cable was altogether inconsiderable.

It was shown by the author of this paper, in the 'Civil Engineer's Journal' for March 1859, that according to Col. Beaufoy's experiments, in such case the friction reduced the statical tension by little more than 1 per cent., and even if the cable were paid out at a velocity vastly greater than could be permitted in practice, the fluid friction would still be small.

It appears however from observation, that the tension of the Atlantic cable in very deep water was less than that which the theory in question indicates, and this discrepancy must, of course, arise from one or more of the hypotheses being inaccurate. The true cause of the discrepancy appears to be that suggested by Prof. Thomson, viz., the undulatory motion of the cable. The above conclusions entirely depend on the assumption that the cable preserves always the same form in descending. If it have an oscillatory motion, the law of its tension may be entirely altered, and it may be easily seen that the effect of oscillation in water may be to greatly diminish the tension. An eel by its wriggling motion is able to overcome the effect of gravity and to ascend in water; and in the same way a sinuous motion of the cable will create resistances which counteract a part of its weight, and consequently reduce the tension.

It may be added, that a theory such as that above considered, though imperfect, is valuable on account of its suggestiveness. It is very probable that, unless the discrepancy between this theory and the practical results had been observed, the remarkable effects of a sinuous motion of the cable would have been overlooked.

In the *Discussion* which followed—

Prof. WILLIAM THOMSON said,—The chief information which I have to produce relates to the rate at which the cable was paid out of the ship; and the amount of tension to which it was subjected in that operation. I have in my hands a log kept in laying out the cable by one of the officers, which shows in the most correct form the experiments recorded. In the first place, on the whole distance to be run from Valentia by the Agamemnon, there was allowed 32 per cent. for slack on the cable. Now it appears that the percentage of slack paid overboard, on one day at all events, considerably exceeded this 32 per cent. which the whole amount of cable on board allowed. There, in fact, lay the great cause of failure of the undertaking. There was another subordinate cause, namely, that we had 208 tons of coals on board which unfortunately proved to be of bad quality. Those coals taken on board at Haulbowline, involved a consumption to a considerably greater amount in proportion than would have been required in the case of the coal with which the navy is generally supplied. With this introduction I shall call atten-

Digitized by Google

tion to the particulars as regards the state of the sea, in connection with the consumption of coal and expenditure of cable during the six days of paying out. During the first two or three days the weather was on the whole favourable.

Leaving on the 29th July, on the 30th at noon the distance made by the ship from the rendezvous was 98 nautical miles; and the length of cable paid out was 135 nautical miles; or fully 33 per cent. for slack on the distance run. It will be remembered that the absolute amount allowed was only 32 per cent.; so that even on the first day there was more run out than could be paid out on the average. From noon to noon between 30th and 31st, the distance run was 103 miles, and the cable paid out was 144 nautical miles; from noon of the 31st to noon of August 1st, the distance run was 127 miles, and the cable paid out 155 miles. During the next four and twenty hours, 127 miles were run and 170 miles paid out. This was most alarming. The result of two more such days would have brought us to an end of the cable, while we should still have been in deep water, short of our distance. On the 29th July the water was smooth and wind south-east, slightly adverse, not permitting us to carry canvass; the strain on the cable was 16 to 17 cwt. A fresh breeze sprung up on the afternoon of that day. On the 31st in the morning moderate gale, wind south south-east, coal burning 50 per cent. more than was expected; greatest fears entertained of running short, though we had considerably more on board than would have reached the shore at the ordinary rate. Here the wind was adverse, though only a very moderate gale, and not a very great motion on the ship. Still the amount of cable paid out was very serious. The time when the greatest amount of cable was paid out was on the day from August 1st at noon to August 2nd at noon, 171 miles paid out, 127 miles run. At this time the wind was south-west, and increased to a fresh gale—fore and aft sails set. At midnight the swell became strong, wind still in the same quarter and equally with showers, ship pitching as much as 7 degrees; it became then apparent that it might be absolutely necessary to take off the weight on the cable, which never was more than 1400 lb. according to the indications of the dynamometer: the actual strain amounted to from 17 to 16 cwt. The resistance was diminished, and the dynamometer indicated from 11 to 15 cwt. Then the cable was in a state which appeared to be very dangerous. It hung nearly vertical from the stern of the ship, and it became soon thereafter a certainty that the shore end of the cable was loose.

The bearing of the theory of Mr. Cox then, is this—It appears that a cable in going out of a ship, if resisted by any force less than that equal to the weight of a portion of cable supposed to hang vertically to the bottom, will go in a straight line only down so far as to a depth corresponding to the tension with which its egress is actually resisted. In calm weather the portion of the cable from the ship down to the depth here alluded to, will be a straight line inclined at some, not large angle to the horizon, and its motions, both relative to the water and absolute, are expressed by a simple geometrical law. A statement of this law was published in the *Engineer* in its report of the communication which I made to the Mechanical Section of the British Association at Dublin, where I believe that law was first stated. Below the point where the cable reaches the depth corresponding to the resistance applied to it where it leaves the ship, the cable is under no tension in any part till it reaches the bottom, and—thus deprived of tension—it is allowed to run through the water at a considerable speed,—one, two, or three knots per hour, according to the amount of slack paid out—that is, according to the difference between the rate of the vessel and the rate at which the cable is paid out.

Even a rigid elongated body cannot, when left to itself, continue moving steadily lengthwise under water any more than an elongated rifle ball can continue moving point foremost through the air without the rotation which the rifle barrel gives it. In the case of the flexible cable, it is obvious that the cable will run into bends, and these bends will twist themselves into kinks before the cable reaches the bottom.

According to the theory of Mr. Cox, to which I assent, it would be necessary in paying out to diminish the check or resistance offered by this system of brakes: I believe twenty cables might thus be laid and not one of them broken. In fact, it was quite certain to myself before going out in the Agamemnon, that the cable must untwist in the part subjected to tension in leaving the ship; and therefore certain that in the lower part under no tension, or under less tension, it must twist up again.

I am aware that many practical men supposed it impossible that the cable could untwist in coming out of the ship, because, as was alleged, both ends are fixed, and therefore of course continued untwisting cannot take place. But this objection to the result which I anticipated, overlooked the twisting up again which must take place in the lower part: and I believe it would make the very hair of some of those who so objected stand on end, to see the cable at the two mile depth! At any rate, the event proved that the cable did untwist at a considerable rate in leaving the ship, although never at such a rate as to do the slightest damage either to the electric condition of the core or to the strength of the cable.

The resistance of the water to the lower part of the cable below the critical point which has been alluded to, acting further on very frequent curved sinuosities, or upon kinks, prevents the lower part from pulling at all upon the upper; and mathematical theories hitherto published apply strictly to the part above this critical point, and to that part alone. This problem of laying a cable in deep sea is reduced, in fact, to that of laying a cable in a selected depth, namely, a depth corresponding to the tension which applies to the cable on its egress from the ship.

The great practical conclusion as regards the engineering part of the problem obtained by the second and successful voyage of 1858 is, that the cable does not run out at the great rate which might have been anticipated either with or without mathematical calculation, on the supposition that considerably less resistance is applied than that corresponding to the whole depth. No doubt the amount of slack taken by the Atlantic cable in running out under the tension which circumstances compelled, in order to avoid the inevitable fracture of the cable at the time, was very serious, and often threatened to exhaust the supply of cable before the shore was reached; but I am of opinion that the amount of slack necessary may be considerably diminished by the use of an elastic contrivance in the paying-out machinery to regulate the egress of the cable in a heavy sea. But, with or without such a contrivance, it appears certain that a cable may be laid, or, as I have said, that twenty cables may be laid in succession across the Atlantic, provided nothing goes wrong in the machinery or on board the ships, and that a fracture overboard may be provided against with almost absolute certainty, by merely diminishing the strain to a small amount, say one-half or one-third of the weight corresponding to the depth. Diminishing to some such amount as that the resistance applied to the cable, seems all that is necessary. And from the theory which has been indicated, as well as from the experience of the voyage, it does not appear that any very great increase of the slack would be produced by diminishing the resistance applied to whatever degree is considered necessary for security.

As to the question of uplifting the cable, I fear that after going into a state of no tension after being in a state of high tension, the task will be an extremely difficult one.

Mr. H. Cox asked Prof. Thomson, whether in his opinion the specific gravity of the cable was too great?

Prof. Thomson said,—It would no doubt be desirable to reduce the specific gravity of the cable by adding materials which give strength or electrical power; but it would be no advantage to add materials which do not increase the strength or electrical power.

Log of Agamemnon referred to by Prof. Thomson.

"After completing coal to 500 tons from Haulbowline, and water to 50 tons, we left Cork at daylight on the 18th July: draught of water forward 23 ft. 6 in., aft 26 ft. 8 in., mean 25 ft. 1 in. (with two boilers filled), mid-port 5 ft. 9 in. In all the better trim for having lost so much cable. The other ships had preceded us by one day, as we waited for Prof. Thomson, one of the directors. We had light winds and gloomy weather; being obliged to reserve the coal, made a long passage. The coal which we received at Cork was so bad that 60 tons would scarcely do the work of 40.

July 29.—Arrived near the rendezvous, found the other ships, and made "the splice" in lat. 52° 8′ N., long. 32° 27′ W. Telegraph-office on White Strand, near Valentia, 815 nautical miles. Cable on board 1078 nautical miles—263 for slack, or 32 per cent. on the distance. Coal remaining 308 tons of bad quality, therefore requiring economy, or an easterly wind would ruin us. All the ships were exclaiming against the coal, and fearing they would run short. The depth where the splice was made is 1550 fathoms. At 1 p.m., having lowered 200 fathoms fairly between the two ships, let go the hawser, and proceeded very slowly: distance run

Digitized by Google

by 2 p.m. was 1·5 knots; cable paid out 5 knots 505 fathoms. In the next hour ran 3 knots; total cable, 11 knots 900 fathoms. At 4 p.m. ran 2·8 knots; cable run out 16·800. At 5 p.m. 3 knots more run—22 miles paid out. At 7.50, the distance run being 25·7 knots, cable paid out 39 miles 700 fathoms. We received a great fright by an injury having been discovered in the cable, 1 fake or 6 miles from the part paying out. It must have been smashed in the gale. It was opened and spliced, or covered afresh with gutta-percha. To stop paying out would be certain ruin, so after stopping, the ship continued to pay out slowly. The repair was complete before the 6 miles were out, and no time to spare. Then they lost continuity; we imagined the cable to be stretched and destroyed near the Niagara by their tests. After the cable was nearly brought to a stand, greatly endangering it, at 9.16 signals came all right from the Niagara. 9.30 proceeded. At 9.50 the Niagara had paid out 40 miles, and at 11.12, 50 miles;—Agamemnon at the same time 48 miles and 59 miles. At midnight our speed was 4 knots. We had paid out 62 miles 320 fathoms. The water had been smooth: strain on dynamometer 11 to 17 cwt., while the ship was stopped 23 cwt. The angle of immersion was 24° to 15° from horizontal.

On the 29th we paid out very equally with the Niagara; she reported by signal every ten minutes.

July 30.—Water smooth, wind S.E. Strain 17 to 16 cwt., as shown in the table. When one number only is given in the columns for strain or angle, the mean is intended. 6.54 a.m. the Niagara had paid out 100 miles; 7 a.m. Agamemnon 105 miles 500 fathoms. 3.21 p.m. Niagara had paid out 150, and at 10.40 200 miles; 11 p.m. Agamemnon 200½ miles: sea getting up.

July 31.—a.m. A moderate gale from S.S.E., overcast with drizzling rain, much swell. Coal received at Cork very bad, burning 50 per cent. more than expected; great fears of running short: p.m. moderate gale, S.S.E., squally, with rain, much swell. 2.33 Niagara paid out 300, Agamemnon 293½ miles. The deepest water 2400 fathoms. Hopes now ran high, checked chiefly by the wind and bad coal.

August 1.—a.m. Strain irregular; men assisting the wheels as her stern fell; wind S.W., at first moderate, increased to a fresh gale. Set fore and aft sails forward, also foresail, to help the coal. At 5.15 a.m. Niagara had paid out 400 miles, Agamemnon 393 miles: p.m. S.W., fresh gale, barometer 29·50, swell heavy, pitching 7°. Set foretopsail double-reefed. 8 p.m. Niagara payed out 500 miles, Agamemnon 493: midnight, swell dangerous to cable.

August 2.—a.m. Fresh gale from S.W., squally, with showers. At 1 an alarm of having lost continuity, soon found to be all right again. 9.17 a.m. Niagara had paid out 600 miles; Agamemnon at 11 a.m. 600: noon, wind more moderate, W.S.W., swell going down. 3 p.m. nearly run into by an American schooner; fired guns, &c., obliged to alter course by four points. Wind shifted to S.W., at first moderate, increased to a fresh gale; set fore and aft sails to help the coal. 4.15 Niagara had remaining 400 miles of cable, and Agamemnon 393 miles. 11.10 Niagara payed out 700, Agamemnon 686·2 miles.

August 3.—Wind W. to W.N.W., moderate and fine, rolling 7° to port and 9° to starboard—not pitching. 8.17, Agamemnon 748½, Niagara 750 miles: p.m. moderate and cloudy, wind S.W. 3.20, Niagara 800 miles. 3.30, Agamemnon 800 miles. 9 p.m. reached the bank, 550 fathoms. Found the strain to leave the cable much sooner. 11.20 p.m. reached 200 fathoms, and made signals to Niagara.

August 4, 0.30 a.m.—Niagara had reached 200 fathoms—about 100 miles off shore. Wind S., moderate and gloomy. No strain on dynamometer, or perhaps 4 or 5 cwt. 4.10 a.m. changed coil from the hold to upper deck. 7.18 Niagara payed out 900 miles; 8.30 Agamemnon 900 miles. P.m. wind N.W. and W.N.W., fine—the first clear day for some time. 8.40 p.m. changed from upper deck to cockpit, where there were 80 nautical miles, distance to the beach being 45½ nautical miles.

There will be nothing more, I hope, to add to this, beyond the cable being coiled in one of the Valentia boats, and put away under three hearty cheers."

Date—noon.	Latitude.	Longitude.	Distance made.	Cable paid out.	Distance from Valentia.	Cable remaining.	Expenditure of coal.	Coal remaining.	Strain by dynamometer.	Angle. Immersion.	Angle. Horizontal.	
			miles.	miles.	miles.	miles.	tons.	tons.	cwt.	degrees.	degrees.	
July 30 . .	52° 24′	29° 50′	98	135·8	718·	942·2	29¼	278	17 to 12	17 to 12	7	A.M.
									11 ,, 19	16 ,, 13	8 to 8	P.M.
,, 31 . .	52° 33′	26° 44′	113	144·2	604·7	798	49	229	9 ,, 16	14	9	A.M.
									9 ,, 15	13	10	P.M.
											midt. 5	
Aug. 1 . .	52° 27′	23° 16′	127	154·8	478½	643·2	52½	176	11 ,, 15	11 to 14	7	A.M.
									11 ,, 14	13	8	P.M.
,, 2 . .	52° 35′	19° 48′	127	170·2	351·6	478	31½	144½	11 ,, 13½	13	5	A.M.
									11 ,, 13	12½	5 to 0	P.M.
,, 3 . .	52° 26′	16° 7′	134	171·8	217·2	301·7	30½	114	11 ,, 13½	12 to 13	0	A.M.
									11 ,, 12	12 ,, 14	2	P.M.
,, 4 . .	52° 11′	12° 40′	128	148·5	89·5	153	28·2	85	nil	14 ,, 24	2	A.M.

NOTE.—By the term miles is meant nautical miles, unless the contrary is stated.

PROF. THOMSON'S ACCOUNT OF THE ACCIDENT OF JULY 29, 1858.

"July 29, 1858.—Immediately after 10 p.m. Greenwich time, at the beginning of what ought to have been the answer to our 40 mile signal, the current from the Niagara failed. Tests then applied showed a breach of continuity, far on the line, with no loss of insulation. As this happened while proceedings in the hold were being taken to put right a piece of the cable which had suffered injury, probably in the gale, it seemed likely that the interior conductor might have sprung in consequence. After repeated trials however, by pricking through the gutta-percha and testing, it was ascertained that the whole cable in the ship up to a point very near the outgoing part, and including the mechanically defective spot, was perfect electrically. The core was then cut at the place of the injury, and the end leading to the outgoing part was tested. The electrical indications still showed the same defect as before.

The insulation was so perfect as to reduce to a very small amount the constant current from a powerful battery; but the capacity of the wire for charge was so great, as to show that the fractured end must be at a considerable distance; probably more than 50 miles, though certainly much less than 200.

The severed conductor was then re-united and tested, and the strands of the cable were put together and secured round it, just soon enough to go overboard when required. Great credit is due to those who conducted this most critical operation in the hold under so urgent pressure of time. An anxious quarter of an hour followed, during which the soundness and strength of the splice were proved by submergence in water 2 miles deep.

The insulation and the want of continuity continuing as before, nothing remained but to wait for at least the time prescribed by the board, paying out only enough to prevent the cable breaking away from the ship's stern. Accordingly, as soon as such a length had been allowed to run out very freely as should put the splice beyond the reach of strain, the brakes were loaded and the ship was moved ahead at a slow rate, so that, while waiting against hope for the recovery of the electric circulation, as little as possible of the cable should be thrown away. A few minutes later (at 11.27 p.m. Greenwich time) the electrical tests showed instead of insulation "dead earth" in some position between the ships, or not far from the outgoing portions in either, and the too probable conclusion that the cable had parted nearly destroyed the little hope that was left. That the cable had been cut on board the Niagara, and had not parted in the sea, became clear, as after three minutes more, that is to say at 11.30, a strong current came through the cable—so much stronger than any that could be expected from the earth as to be only attributable to

Digitized by Google

the batteries in the Niagara, and signals were now interchanged between the two ships. Immediately the brakes were released, and the Agamemnon was moved ahead up to regular speed.

At 12.0 (midnight, Greenwich) the Niagara signalled 40 miles paid out; and at 12.30 the signal from the Agamemnon was '50 miles.'

The electrical tests continued to indicate earth in the same position as before, until some time between 12.20 and 12.30, when it appeared the Niagara's cable must once more have been thrown into circuit.

Until intelligence is received from the other side of the Atlantic, it is impossible to say for certain where the breach in the conducting wire was: if it had been beyond the point where the Niagara cut, we should probably have found 'air' not 'earth' during the time which passed before their battery was applied to the cut end; and it therefore seems more probable that it was between us and that point, and must have come together again while those in the Niagara were waiting for signs of continuity after they had cut, and we after we had cut and mended."

Abstract of a paper on Gutta-Percha as an Insulator at various Temperatures, by Fleeming Jenkin, C.E.

Communicated by Prof. W. THOMSON.

THE following paper contains an abstract of the results of some experiments made for Messrs. Newall and Co. at their establishment at Birkenhead, to determine the absolute resistance of gutta-percha, and the effect of temperature on that resistance. No satisfactory comparison can be made between any two cables, or between the different tests of any one cable, until this effect has been thoroughly investigated; and it is hoped that the following paper, which Messrs. Newall have kindly permitted the author to lay before the association, may prove the forerunner of fuller and more perfect researches.

The absolute resistance of gutta-percha at different temperatures has been calculated from the daily tests made at Messrs. Newall's establishment, and the variation of resistance in a short length immersed in water at similar temperatures has also been observed. The results obtained by these two methods of investigation agree pretty closely.

The cables at present manufactured however, do not consist of pure gutta-percha only. A coating of a varnish called Chatterton's Compound is first applied to the copper wire, a layer of pure gutta-percha is then applied, this is covered by a layer of varnish, followed by another coating of gutta-percha, and the process is repeated until the desired thickness of insulating covering is arrived at. This process was supposed to improve the insulation of the cables, and in order to test the value of the improvement at all temperatures, two coils of gutta-percha covered wire procured from the Gutta-percha Works, Whairoad, London, of precisely similar weight and dimensions, one of which was covered according to Chatterton's patent, the second with pure gutta-percha only. The length of each cable was one nautical mile. The diameter of the gutta-percha was in both cases 0·3 inch, and that of the copper wire 0·06 inch.

These coils were ascertained to be perfect by tests under vacuum and pressure, and then removed into a wooden tub carefully felted. This tub was filled with water, the temperature of which was changed from day to day, care being taken to make no test until the coils should have remained for about twelve hours in water of a nearly constant temperature, in order to ensure a uniform heat in the entire mass.

The loss or escape of electricity at each temperature was measured by the ordinary test for insulation, on an extremely delicate sine galvanometer manufactured by Messrs. Siemens and Halske. In this instrument 20,188 turns of fine copper wire surround the lower magnet of an astatic couple, which is suspended by a single silk fibre about 7 inches long. The position of the needle is observed by a lunette and prism obviating all parallax, while by the aid of a vernier observations can be made with the greatest nicety.

Separate tests were made with the positive and negative poles of the battery connected to the coils, and at each test five readings were taken; the first one minute after the application of the current, the others at successive intervals of one minute: the last test, therefore, was made five minutes after the first application of the current. Thus at each temperature ten tests were made, each checking the accuracy of the others. On coil No. 1, covered according to Chatterton's patent, a very marked and singular difference appeared between the tests made with positive and negative currents; whereas in coil No. 2, one table will serve to express the results of the experiments for all temperatures between 50° and 75° Fahrenheit. In both coils and at all temperatures observed, the loss on current passing through the gutta-percha decreased rapidly during the first two minutes, and at the end of five minutes a minimum was in almost all cases nearly attained. This effect in coil No. 2 was extremely regular, and for all temperatures between 50 and 80 was not affected by changing the pole of the battery connected to the coil. In coil No. 1 the decrease of loss was regular, and nearly constant when the zinc pole was connected with the coil, whereas most irregular results were obtained when the copper pole of the battery was so connected.

This increase of resistance or decrease of loss was still more marked in a coil of Red Sea core, in which the gutta-percha is of much larger diameter. In this coil the loss decreased 30 per cent. during the interval separating the first and fifth minute. A similar diminution of loss after continued or repeated application of a current of the same denomination is observed on long lengths, as is shown by the following experiment:—410 nautical miles of Red Sea cable were tested for insulation on a delicate tangent galvanometer; the positive pole of the battery was first connected with the cable. The needle, when the oscillations first ceased, stood at 57½°; one minute after the application of the current, however, the needle stood at 53½°, after two minutes it had reached 52°, and after five minutes 50½°. On reversing the current the first indication was 61°, but after one minute the needle had reached 54°, and after five minutes 48¾°. On again reversing, the first indication was 61° in place of 57½°. The loss here, therefore, had decreased during the interval of four minutes no less than 26 per cent., and from the first to the fifth minute 16 per cent. The same effect is observable on all the coils as manufactured.

We thus see that a gutta-percha covered wire is improved in insulation by the continued application of either a positive or a negative current, and that such improvement does not necessarily indicate the existence of a fault, although it is well known that a similar effect is produced to a still greater degree in a faulty wire.

It also appears from the above, that in keeping a record of insulation tests, it is very necessary to note whether the loss given was observed immediately after the reversal of a current, or after the wire has remained charged for some time, and the loss in consequence become a minimum. It will also be observed that the above phenomenon does not depend on the cable being immersed in water, although probably depending on the polarisation of the molecules of moisture occupying the pores of gutta-percha.

TABLE I.

Temperature.	Loss after first minute. Zinc to coil.	Copper to coil.		Loss after second minute. Zinc to coil.	Copper to coil.
50	125	110	...	100	92
55	136½	122	...	116½	100
60	147	144	...	127	122
65	157½	133	...	137½	102
70	168	140	...	148	102
75	178½	174	...	158½	146
80	190	170	...	170	130

TABLE II.

50	59	59	..	45	45
55	86	86	...	69	69
60	116	116	...	98	98
65	154	154	...	135	135
70	218	218	...	195	195
75	315	315	...	290	290
80	455	445	...	425	405
83	550	535	...	520	495

TABLE III.

60	153	150	...	102	112
65	182	190	...	113	125
70	225	245	...	130	147
75	290	320	...	185	180

The irregularity of the third and fifth columns in table No. 1 is very marked, and in the complete curve as drawn, the changes of curvature are most singular. The number of observations on which the curve depends is so large that the author can hardly suppose errors of observation to be the sole cause of this irregularity.

Digitized by Google

The zinc tests of the same coil were extremely regular. It will be observed that at 65° the two coils test much alike, that at high temperatures the pure gutta-percha rapidly deteriorates, and coil No. 1 has the advantage, but that at low temperatures simple gutta-percha tests much better than the compound.

The irregularity of the copper tests in No. 1 coil might lead to some suspicion of a chemical action taking place between the varnish and the gutta-percha, but such action must be extremely slight even if perceptible; and lastly, it is quite possible that the coil sent down for experiment may be in some part defective, or not a fair sample of the manufacture.

Should the results obtained from this coil be confirmed, the employment of Chatterton's patent would be injurious to the insulation of a cable when submerged in water of a temperature inferior to 65°.

It should be observed that the influence of the compound would be much more marked in such a wire as composed coil No. 1, than in the Red Sea or other large cores, where the patent compound forms a much smaller percentage of the whole covering.

By the above experiments however no absolute measurement of the loss is obtained, whereas it is obviously desirable, in order directly to compare the condition of any two cables, to express the loss of electricity from defective insulation in absolute units. This is most readily done by considering the gutta-percha as a conductor offering a very high resistance to the passage of electricity, and measuring this resistance by comparing it with the resistance of the copper wire, which can of course be expressed in any convenient measure. The ratio of the strength of the current circulating through the copper core joined, so as to form a metallic circuit, to that of the current escaping through the gutta-percha covering, gives the ratio of the resistance of the gutta-percha covering to that of the copper core added to the batteries and galvanometer. This latter resistance is easily obtained in any desirable units.

The actual resistance of any length of any covering being thus obtained, the following formula, due to Prof. Thomson, affords the means of determining the specific resistance, that is to say, the resistance of a cubic foot of gutta-percha in the same units.

$s = R \frac{2\pi l}{\log \frac{a}{b}}$, where R = resistance of cylindrical coating, 2 the length of wire tested, $\frac{a}{b}$ the ratio of the diameter of the copper core to that of the gutta-percha covering. Calculated by the above formula, the specific resistance of gutta-percha found by a selection from our daily tests of the Red Sea and Alexandria and Candia cables, was found to be $= 205 \times 10^{18}$ absolute British units.

The author observes that the above number does not express a well defined resistance such as that of metal, constant at a constant temperature; the resistance of gutta-percha is not constant even at the same temperature for two consecutive instants, so that although this number pretty accurately represents the resistance of gutta-percha about thirty seconds after the application of a current, still owing to the somewhat uncertain increase of resistance, supposed to be due to the polarisation of molecules of moisture in the gutta-percha, tests made under different circumstances, even with the same electromotive force, will give results varying 10 or 12 per cent. from the above number.

The resistance of gutta-percha is, of course, inversely proportional to what in the first portion of this paper was termed the loss; that is to the strength of a current flowing through the gutta-percha; the resistance therefore of different temperatures would be inversely proportioned to the numbers given in these tables.

The coverings of neither wire employed in these experiments were, however, similar to that of the Red Sea cable. In No. 1 the proportion of Chatterton's compound to gutta-percha was larger than in the Red Sea cable, whilst in No. 2 the compound is entirely absent: the curve therefore obtained from the Red Sea cable will occupy an intermediate place between those obtained from the two other wires.

Some rather hasty experiments give in table No. 3 the relative losses through the Red Sea gutta-percha at different temperatures. The unit representing the loss is the same in the three tables.

The resistance of one unit of Red Sea covering corresponding to the specific resistance of 205×10^{18} units is at 60°, 285×10^{13} units. The resistance of the covering of No. 1 coil is found by comparison with the Red Sea coil to be 356×10^{13}, whilst the coating of No. 2 coil has a resistance for the same length of 369×10^{13}. The specific resistance of each coating, calculated by the formula given above, is 202×10^{18} for No. 2 coil, and 195×10^{18} for No. 1 coil. The specific resistance of good copper may be taken as equal to two units.

Prof. Thomson's formula enables us to calculate from the annexed tables what may be expected to be the resistance of any similar coating of any proposed cable. The employment of Chatterton's compound in different proportions from those used in the above coils would, however, necessitate fresh experiments in each case on one or more nauts, to determine the effect of temperature and to obtain the resistance of the new coil at some one temperature at least, compared with some old and known cable. The author intends to extend the experiments described in the above paper, and to communicate to the Royal Society a detailed account of the entire course of experiments and of the calculations adopted.

The author is sensible of many imperfections in his work, and by no means presents the above results as final. The precautions taken to ensure a perfectly uniform temperature may have been insufficient, and the entire results may have been vitiated by the presence of a small length of bad material. Frequent repetitions of such experiments can alone give perfect confidence in the results obtained, and the author will be be the first to welcome any further and better efforts in the same direction.

On the Stratified Electrical Discharge as effected by a Moveable Glass Ball. By J. P. Gassiot, V.P.R.S.

If the discharges from an induction coil, when taken in a good carbonic acid vacuum tube, are examined with care, it will be seen that the stratifications nearer the negative terminal are remarkably clear and defined, oftentimes showing clearly separated cloud-like terminations, but gradually becoming indistinct and intermingled with each other towards the positive terminal wire. This difference in the character of the stratified discharge becomes more perceptible to a certain extent as the vacuum improves, for when the stratifications are close and narrow they are regularly diffused throughout the entire length of the luminous discharge.

In a tube 48 inches long and 1¼ inch wide I inserted a small bead of Uranium glass about ¼ of an inch in diameter: transparent Uranium glass, Prof. Stokes has shown, has the property of becoming opaque by the electric light, and this is very beautifully shown in these tubes, but more particularly when the negative discharge is made to impinge upon the bead. If during the discharge the tube is inclined so as to permit the bead to roll down, the discharges will give the appearance as if a distinct row of separate beads were present: this appearance arises from the number of discharges which take place during the rotation, each discharge separately and distinctly illuminating the bead.

The peculiar phenomenon which I however desire to bring before the notice of the section is one which I very recently noticed.

I have already stated that the stratifications near the positive wire are indistinct, but if the glass bead is placed near the positive wire and then allowed slowly to descend towards the negative, the stratifications at the positive are at first as clearly defined near that terminal as at the negative, and as the bead rolls gently down they have the *appearance* of following the bead and issuing one after the other from the positive wire, until the bead reaches to within a few inches of the negative, when this action gradually ceases. If the tube is now inclined so as to allow the glass bead to return in the contrary direction the stratifications *appear* to recede, becoming clearer and clearer defined until the bead passes the positive terminal wire, when the entire discharge returns to its normal state.

On an application of Quaternions to the Geometry of Fresnel's Wave Surface. By Sir Wm. Rowan Hamilton, LL.D.

Sir William Hamilton commenced by explaining the relation of Fresnel's wave surface to the velocity of light in crystals; and then proceeded to show how the celebrated equation of Fresnel could be represented in the language of Quaternions. The following is an abstract of his method:

Let ρ = vector of ray-velocity; μ = index-vector, or vector of wave-slowness; $S\mu\rho = -1$, $S\mu\delta\rho = 0$, $S\rho\delta\mu = 0$ (equations of reciprocity); $\delta\rho$ = vector of displacement, or of vibration; $\phi^{-1}\delta\rho$ = vector of elasticity, or of total resulting force of restitution (ϕ being the same symbol of operation as in the Seventh Lecture on Quaternions, by the present author); $\mu^{-1}\delta\rho$ = a vector representing the tangential component of elasticity);

Digitized by Google

$\therefore (\varphi^{-1}-\mu^{-2})\delta\rho$ = normal component of elasticity $=\mu^{-1}\delta m$, δm being a scalar; $\therefore \delta\rho=(\phi^{-1}-\mu^{-2})^{-1}\mu^{-1}\delta m$; and $S\mu^{-1}\delta\rho=0$; $\therefore$ the formula

(*a*) . . . . . $0=S\eta^{-1}(\phi^{-1}-\mu^{-2})^{-1}\mu^{-1}$

is a *Symbolical Form of the Equation of the Index-Surface*, or of that surface of wave-slowness to which the wave itself is *reciprocal*. Hence, by the equations of reciprocity given above, or simply by changing μ to ρ, and φ to φ^{-1}, we obtain the formula

(*b*) . . . . . $0=S\rho^{-1}(\phi-\rho^{-2})^{-1}\rho^{-1}$

as a *Symbolical Form of the Equation of Fresnel's Wave.*

To *interpret* this equation, or to deduce from it a *geometrical construction*, we may observe that the formula (assigned in the Seventh Lecture)

(*c*) . . . . . $1=S\rho\phi\rho$

is the equation of a certain *Auxiliary Ellipsoid*; and that $s=\rho^{-1}\surd\rho\phi\rho$ $=\phi\rho-\rho^{-1}=(\phi-\rho^{-2})\rho$ is a vector perpendicular to the plane of that diametrical section whereof ρ is a semi-axis. Hence, $0=Ss\rho=Ss(\phi-\rho^{-2})^{-1}s$ is an equation which determines the two values of the square $(-\rho^2)$ of the length of a semi-axis of the diametrical section made by a plane perpendicular to s; and if $\tau s=\tau\rho$, so that the normal s to the plane of the section is made equal in length to one or other of the two semi-axes, then

(*d*) . . . . . $0=s(\phi-s^{-2})^{-1}s$.

But this is just the equation (*b*) of the Wave, with s written instead of ρ. Hence then is at once derived the celebrated Construction of Fresnel,—namely, that "the Wave Surface (for a biaxal crystal) is the locus of the extremities of normals to the diametral sections of an ellipsoid, each normal having the length of one of the semi-axes of that section."

The following *Report of the Committee on the Patent Laws* was read in the Mechanical Section:

At the meeting of the British Association at Leeds, for the year 1858, a committee was reappointed for the purpose of taking such steps as may be necessary to render the patent system of this country, and the funds derived from inventors, more efficient and available for the reward of meritorious inventors and the advancement of science.

No reply has been received from the Commissioners of Patents either to the memorial of the Glasgow Committee of the British Association, or of the public meeting in Manchester; but some of the questions referred to in those memorials are adverted to in the report of the commissioners just issued. From that report, it appears that the number of applications for patents may be estimated at about 3000 per annum—that of these 3000 applications, not more than about two thousand proceed to the final stage of a patent; and that of the two thousand patents granted not more than 550 are kept alive beyond three years by the first periodical payment of £50 before the expiration of that term; and the commissioners anticipate that the fee of £100, payable at the end of the seventh year, will not be paid on more than 100 of the surviving 550 patents. Should this anticipation prove correct, the payment by inventors in fees upon patents not surviving beyond one-half their term of fourteen years, will not be less than at the rate of £100,000 per annum, as a direct tax on the inventive genius of the country, in addition to and exclusive of time, labour, and other charges and expenses. The total outlay in respect of those patents may be estimated as at least £250,000, or a quarter of a million per annum. The great work of printing and publishing *in extenso* the specifications of patents, granted under the old law—that is, from 1711 to the 1st October 1852, in number 12,977—is completed, and the surplus funds hitherto absorbed by this object will be henceforth available for other purposes. That surplus is estimated by the commissioners at £30,000 for the current year 1858-9, and to increase in each succeeding year at the rate of £20,000 per annum. This surplus, after providing for the current expenses, is proposed by the commissioners to be appropriated to the following objects:—

1. The erection of a museum for the preservation and exhibition of models, of which a considerable collection already exists at Kensington.

2. The erection of suitable offices for the commissioners, including a free library of consultation, upon a more extended scale than already formed by Mr. Woodcroft.

These most desirable and legitimate objects for the application of the "Inventors' Fee Fund," cannot however be attained without the sanction of the Lords Commissioners of Her Majesty's Treasury and a vote of Parliament, inasmuch as all the fees levied on inventors are, by a recent change, levied in the shape of stamps, and so pass directly into the consolidated fund. These recommendations of the commissioners will, it is conceived, be regarded as a most legitimate application of the funds of inventors, and as one to which the parliamentary committee of the British Association will give their aid, but your committee think that other considerations and other claims upon the Inventors' Fee Fund, and upon the annual surplus, whatever its probable amount, should be forthwith urged upon the commissioners and upon parliament.

The report of the Patent Committee of the British Association to the Leeds meeting called prominent attention to the two following questions:—

1st. Whether the present scale of payment would be maintained or reduced so as to leave no greater surplus than necessary for official expenses?

2d. If the present scale of payment be maintained, how shall the surplus be appropriated?

The commissioners of patents are in favour of maintaining the present scale of payments, on the ground "that any material reduction in the amount of fees, would undoubtedly tend to increase the number of useless and speculative patents, in many cases taken merely for advertising purposes.

Your committee are not insensible to the force of this observation, but they beg respectfully to doubt whether this money check has any effective operation on the class of cases most requiring to be controlled, and whether the remedy is not worse than the disease in laying an unjustifiable burden on the inventive genius of the country, and effecting confiscation of property of its own creation.

Your committee are much struck with the fact that the application for about 1000 patents is not prosecuted to completion, and in many cases probably not beyond the first stage; and that the first periodical payment of £50 at the end of the third year is not made in respect of nearly 1500 of the 2000 patents granted; and that the commissioners anticipated during the ensuing year the surrender or lapsing of no less than 450 out of the 550 patents which survived the first periodical payment.

It must be borne in mind that the granting of patents in this country is practically without control, no attempt having been made to interpose any of the checks urged before the committee of the House of Lords, in the session of 1851, and provided for in the three bills of that session, and in the leet of the subsequent session, now the law of the land. The payment of £5 on the first application may be regarded as a registration fee; the applicant makes this payment on lodging the papers, obtaining protection and inchoate rights from the moment of his application. This was one of the cardinal features of the new system of 1852. It has been productive of the greatest benefit to inventors, especially to those of the poorer class, by enabling them to obtain inchoate rights, and to create property for themselves by a simple record of their inventions without publicity and the obstruction of interested opponents. This power of placing inventions on record is also resorted to in many cases by those who do not wish further to secure or appropriate to themselves property in their ideas and inventions, which forthwith become public property. The 1500 lapsed patents must be regarded in a different light. These have cost their authors no less than £37,500 for fees and stamps as a direct taxation on their inventive genius, in addition to, and exclusive of, other payments of at least an equal amount. Of these 1500 patents it is believed that the progress of at least 1000 might be arrested with the *consent* of the applicants, if the inquiry before the law-officers were substantial instead of merely nominal. Thus a large useless outlay of capital in money and time would be avoided,—talents unprofitably employed would be directed into other channels, and the creation of legal rights would be limited and reduced, exactly in proportion as the applications were not proceeded with.

Your committee conceive that the application of a portion of the funds contributed by inventors would be most properly applied to affording them this species of protection against the unprofitable expenditure of time and money.

The reward of the meritorious inventor, in cases in which he alone of the public has failed to benefit by the fruits of his genius and the purchase of patent rights in him of extending their terms, was referred to in the report of the Patent Committee of the British Association at the Leeds meeting, as a legitimate appropriation of a portion of the surplus.

These objects being satisfied, a very large surplus would remain available for the advancement of science, by researches having a direct bearing on the reproductive industry of the country. And if it be thought expedient that more money should be levied on the granting of patents than necessary for the expense of the office, inventors have, it is conceived, an irresistible

Digitized by Google

claim for the expenditure of that surplus upon objects bearing on their interests and the advancement of science.

W. Fairbairn. Edward Sabine. Thomas Webster.

In the discussion which ensued, Mr. W. Fairbairn, F.R.S., V.P., laid before the meeting the Memorial of the Manchester meeting, and expressed his concurrence in the suggestion for the reduction in the cost of patents, or, at all events, that any surplus should be rigidly applied to objects in which inventors have an interest.

Mr. R. Roberts.—The suggestion as to the cost of a patent being limited to £25 was a delusion; the cost was more nearly £125. No patent ever paid under seven years, and very few under ten years. He did not see why inventors were to be subject to such an infliction or penalty for doing good to their country. If the object was to obstruct improvements, the legislature adopted the most efficient means for that purpose. No committee was competent, even if honest, to have the rejection of inventions entrusted to them. He would let inventors have patents at their pleasure, and leave it to litigation or natural death to remove them out of the way.

The Right Hon. Joseph Napier suggested that a copy of the report should be sent to the Social Science Association, about to meet at Bradford, and that the requisite improvements in legal proceedings for the protection of the interests of patentees should be the subject of a paper, which he would be happy to support. He had always disapproved of the proceedings before the law officers. He felt ashamed, when a law officer, of having to discharge, without assistance, the duties which they were supposed to discharge, but which was only a mode of paying the law officers.

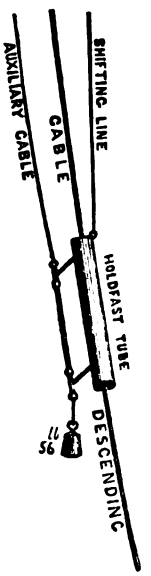
Prof. Willis, F.R.S.—One difficulty was, that many persons in perfect honesty reinvented and reproduced inventions which had been tried and failed. Inventors wanted protection against themselves and their own inexperience. They had not the means of knowing what had been done; this opportunity ought to be afforded them; they were entitled to have that information afforded them. They were also entitled to have protection against others who lay in wait, making slight alterations, such as would suggest themselves to any person, and obtained patents for their so-called inventions, which they used for obstruction. Inventors ought not to be taken by surprise, and prevented, when their means were exhausted, from reaping the fruits of their inventions. They were entitled to be protected against themselves and the unfair dealings of others.

(*The Report of Proceedings will be continued in our next.*)

NEW METHOD OF RAISING AND SUBMERGING TELEGRAPHIC CABLES.

The following is an extract from a description of a method invented by Mr. Patrick M'Grade for raising and submerging submarine telegraph cables. The object of the inventor is to relieve the cables from a great part of the strain of their weight while passing through the water. This object is proposed to be effected by passing the cable through tubes, which can be made to *clip* it, and which tubes are themselves suspended by auxiliary cables, which thus bear a great part of the strain. It appears however to us that there would be great delay in raising and lowering the tubes at recurring intervals; and, if we do not mistake, the ship would have to be stopped periodically on account of these processes.

"I first make an iron tube, say three feet long, of square shape, oblong, open at both ends. Into this tube I fix two iron bars of its length and two inches square; each one of the bars is securely fastened at the side, or, we may say, the bottom of the tube, when horizontal; the other bar is fixed to two strong levers, which press it firmly against the bar at the bottom, or raise it when required; if you pull the levers towards you it forces the top bar against the bottom one, and any rope or chain that may be between them will be held fast; if you push the levers from you they open and allow any rope or chain that may be between them to pass through freely. To these levers I attach a strong rope of any required length, and also a weight; if you hold the tube now perpendicular, the weight will act on the levers so as to separate the iron bars, but if you haul on the rope you will close them, for the opposition of the weight of a few pounds is not much when there is tons, perhaps, on the rope; but if you let the rope slack, the weight acts and opens the tube; this tube I call the holdfast tube, and the rope I call the auxiliary cable. If you take the shore end of a submerged cable, and put the end of it through the holdfast tube, making the end of the cable fast to the shore again, let the holdfast tube run down to the bottom, the auxiliary cable allowed to run slack, then haul on the auxiliary cable, and it closes the bars on the submerged cable, with a force in proportion to the resistance it gives in coming to you. Suppose the ship now in deep water, say a mile deep, and that you let down three or four of these holdfast tubes in a similar way, the first one down to the bottom, the second within a quarter of a mile of the bottom, the third within half a mile, and the fourth within three quarters of a mile of the bottom, then haul on the four auxiliary cables simultaneously till the last one that went down comes to the surface, and you will have some idea of the weight or *strain* on the auxiliary cables, and consequently off the submerged cable. Hold now the auxiliary cables of the three holdfast tubes nearest the ship taut, and let the one nearest the bottom slack, the weight on the lever of the holdfast tube then acts and separates the bars as before, and so allows the holdfast tube to run down again to the bottom; hold its auxiliary cable now taut, and let the second one slack, it will run down in the same way, holding it tant. When it reaches within a quarter of a mile of the bottom, or some average distance, then the third; and so on, till they are all lowered to their proper depths, ready to be hauled up again, and never allowing more weight to come on any part of the submerged cable than the distance from one holdfast tube to the other, and as the holdfast tubes can be increased to any required extent, so can the weight on the submerged cable be reduced to any required extent.



I have so far shown the manner of hauling up the submerged cable without *straining*, I will now illustrate the manner of submerging it without *straining*. Suppose we now haul on the four auxiliary cables that have been let down, and draw them and the submerged cable up until the last holdfast tube that went down comes to the surface, we have then one mile of the submerged cable resting on four auxiliary cables, each equal in strength to itself. Now, if we lower them gradually down together, same as they were hauled up, until the lowermost holdfast tube reaches the bottom, we have then one mile of the cable lowered one quarter of a mile without *strain*. If we hold the three auxiliary cables of the holdfast tubes nearest to the bottom taut, and let the one nearest the ship slack, the weight on the tubes' levers, as described before, separates the iron bars and allows the cable to pass through them freely. Now, if we had a small line fastened to the holdfast tube, but not to its lever, we could draw it up to the surface; then holding its auxiliary cable taut and letting slack the auxiliary cable of the holdfast tube next to it, and with the shifting line, we in the same way draw it up within a quarter of a mile of the one at the surface, the same with the next, and so on, until we have them all up to their proper place; they are then ready to be lowered another quarter of a mile or so to the bottom, then to recommence drawing them up separately to take a fresh load and go down. Let us now suppose that there are four holdfast tubes in front of the ship, held by their auxiliary cables at equal distances from the bottom to within a quarter of a mile of the ship, and that there are four more holdfast tubes held by their auxiliary cables at equal distances from the stern of the ship to within a quarter of a mile of the bottom, if we now splice the auxiliary cable of the holdfast tube nearest to the bottom in front of the ship to the auxiliary cable of the holdfast tube nearest the ship at the stern, and also the others in the same manner, we will have the two operations, raising and lowering, performed at the same time, and with but a trifling power on the windlass; for, as the weight going down at the stern will be always equal to the weight coming up at the bow, to overcome the equilibrium is all that will be necessary, and the same will be the case in lifting one cable altogether into the ship, if we let another of equal weight out at the same time. The weight of the auxiliary cables themselves are not to be taken into account, as I propose to make them buoyant."

Digitized by Google

DEODORIZATION OF SEWAGE.

THE following report has been addressed by Dr. Hofmann, F.R.S., and Dr. Frankland, F.R.S., to the Metropolitan Board of Works:—

Having been requested by a resolution of your Board, bearing date the 27th day of May, 1859, to undertake the duty of advising the Board as to the selection, from the various schemes proposed for the deodorization of sewage, of a process combining both efficiency and economy, we now beg leave to report to you the result of a minute inquiry into this subject.

In conducting our investigation we have carefully kept in view the final plan of dealing with the sewage adopted by the Board, the principal features of which were lucidly described to us in a letter from your chief engineer.

Not the least arduous part of our labours consisted in the careful examination of the numerous and in many cases ponderous documents addressed to the Board on this subject, and transmitted to us for consideration. Short abstracts of these proposals will be found in the Appendix.

This examination led us to the conclusion that a comparatively very small number only of these proposals admit of application in conformity with the plan of dealing with the sewage finally adopted by the Board.

The comparatively small number admitting of such application experienced a further limitation when the several processes were submitted to experimental trial. In fact, of all the proposals, old and new, referred to us, there is only one which appears to satisfy in the necessary degree the conditions involved in the circumstances of the case.

The agent to which we allude is that described as "Dales' Muriate of Iron," essentially a concentrated solution of perchloride of iron, the disinfectant properties of which were some years ago pointed out by Mr. Ellerman. This we have submitted to an extensive series of comparative trials with the well-known disinfectants, lime and chloride of lime, which, probably owing to their long-established character, are not included in the proposals before us.

These trials lead to the conclusion that the deodorization of sewage may be effected either by the perchloride of iron, chloride of lime, or lime; but that, if quantities of equal value* be applied, the perchloride of iron is markedly superior to either of the others, whilst chloride of lime acts much more powerfully than lime.

These statements refer both to the immediate action of the three agents upon sewage, and to the permanency of the effect produced; but when examined from the latter point of view, the superiority of the perchloride of iron is exhibited even in a still more marked degree.

It may be stated that these results were obtained by operating upon sewage such as flows from the mouths of the chief metropolitan sewers during the hottest season of the year, our experiments having been performed during the latter half of the month of July.

Since the calculations as to the cost of deodorization are based upon these experiments, it may not be out of place here to mention briefly the mode in which they were conducted. In order to enable us to operate upon a sufficiently large scale, brickwork tanks lined with cement, and holding 7500 gallons each, were constructed at the outfall of the King's Scholars' Pond Sewer. The sewage was lifted into these tanks by means of a steam pump, and the various deodorizing agents were incorporated, either by their gradual introduction into the shoots during the process of filling, or by diffusing them through the mass of the liquid by means of mechanical agitation.

From a number of experiments thus conducted, it appears that each of the three agents above mentioned will effect the immediate deodorization of 7500 gallons of sewage when applied in the following proportions:—

Perchloride of iron	½ gallon
Chloride of lime	3 lb.
Lime	1 bushel

* We have endeavoured to arrive at the average prices of these three agents. It appears that they are subject to considerable fluctuation. As the average result of our inquiries, we have taken the value of lime at 9*s.* per cubic yard = 18 bushels; the value of chloride of lime of 36 per cent. (about the strength of that used in our experiments), at £12 per ton; and that of the perchloride of iron solution, specific gravity 1·45, at 6*d.* per gallon. Probably these prices would be subject to a certain amount of reduction if very large quantities were consumed. We should state further, that the estimation of the value of perchloride of iron is founded upon our knowledge of the price of its ingredients and the cost of manufacture, although Messrs. Ellerman and Dales, who have proposed this liquid, quote 1*s.* 6*d.* as their maximum price per gallon.

From these results it follows that 1,000,000 gallons of sewage require respectively:—

66 gallons of perchloride of iron, costing ...	£1 13 3
400 lb. of chloride of lime	2 2 10½
132½ bushels of lime	3 6 6

During the performance of these experiments, which as already stated were made during the hottest portion of a dry season, we were surprised to find that the liquid flowing from the outfall of the sewer was by no means strongly offensive; it was only after preservation in tanks for twenty-four hours, or upwards, that a really powerful odour manifested itself. This circumstance rendered it of the highest importance to inquire more closely into the degree of permanency of the effect produced by the several agents under consideration.

For this purpose three equal quantities of sewage were collected, and perfectly deodorized respectively by perchloride of iron, chloride of lime, and lime: they were then allowed to stand. After two days, the sewage disinfected by lime became slightly tainted, whilst that deodorized by chloride of lime and perchloride of iron remained perfectly odourless. At the end of three days, the lime sewage had become decidedly offensive, whilst the other two specimens still remained free from smell. After four days, the odour of the lime sewage had become worse, but that treated with chloride of lime likewise began to exhibit an offensive character, whilst the sewage to which perchloride of iron had been added remained perfectly inodorous. Even after the lapse of nine days, the condition of the latter had not changed. In other experiments the same relative permanency of effect has been observed.

Another important element in estimating the comparative fitness of an agent for the treatment of sewage is, the time required for clarification after the addition of the disinfectant. In this respect also the results of the preceding experiments lead us to give a decided preference to perchloride of iron.

It now remains to apply the results thus obtained to the circumstances of the case before us. From the statement in Mr. Bazalgette's letter, it appears that it is at present contemplated to collect the larger proportion of sewage in two reservoirs, to be constructed respectively at Barking Creek and Crossness Point, in which it would be allowed to settle for about nine nours and a half, in order to be discharged into the river during the first two hours and a half of the ebb tide. The third portion of sewage, we learn from Mr. Bazalgette's letter, will be pumped into the river all the year round at a point near Cremorne Gardens, termed the outfall for the Western Division. The subjoined table gives the quantities of sewage discharged at present daily, according to Mr. Bazalgette's estimate, and likewise the quantities anticipated in future years.

	Present.	Prospective.
Discharge of sewage at Barking Creek ...	56,536,875	62,500,000
,, Crossness Point...	20,066,250	35,937,500
,, The outfall of Western division	4,646,875	9,375,000
Total	81,250,000	107,812,500

The sewage discharged at Barking Creek and Crossness Point would probably not require deodorization, except during the hot season of the year, say during three months. Supposing the deodorization to be effected by perchloride of iron, the disinfection of this portion of the sewage at the present rate of flow would involve an expenditure of £11,620 13*s.* 9*d.* for the three months. We are however of opinion, that in practice the sewage discharged into the river at this distance from the metropolis would rarely require deodorization for so long a period as three months. In fact, we are not without hope that the sewage, supposing it to arrive at these outfalls in a condition similar to that in which it is at present discharged from the King's Scholars' Pond Sewer, would, when properly freed from suspended matter, only require deodorization under particularly unfavourable circumstances.

With regard to the sewage discharged at the outfall of the Western Division, it will be indispensable to submit it to a systematic deodorization the whole year round. Owing to the comparatively small fraction of the sewage delivered at this point, a very moderate sum would cover the expense—£2821 3*s.* being the cost of the disinfectant for the year.

Having thus stated the results of our experiments regarding

Digitized by Google

the process of deodorization, it remains only to draw particular attention to the importance of discharging the sewage into the river as free from mechanically suspended matter as possible. We have found that this suspended matter, when separated even from the deodorized sewage, rapidly passes in warm weather into a state of active putrefaction. The removal of this matter would, in a great measure, prevent the formation of any offensive deposit upon the banks of the Thames, not to speak of the improvement in the appearance of the river which would thus be secured. We are therefore of opinion that filtration should be invariably employed at the outfall of the Western Division, and that subsidence, if not actual filtration, should be resorted to at the two remaining outfalls.

The putrefactive tendency of the deposit separated by filtration or subsidence, renders its rapid removal from the reservoirs or filters a matter of the utmost importance, especially during summer; for the process of putrefaction, when once commenced, can be arrested only by quantities of disinfectants practically impossible.

It is not within our province to enter into details respecting the mechanical arrangements necessary for the application of the disinfectant, or for the filtration and subsidence of the sewage; but we beg to express our opinion, based upon the experience acquired during this investigation in manipulating with comparatively large quantities, that the disinfection of vast volumes of sewage can be more easily accomplished than is generally believed, and than we ourselves anticipated at the commencement of our inquiry. The actual process of deodorization will probably present less difficulty than the mechanical separation of the deposit by filtration or subsidence. This separation will involve the temporary storage of immense quantities of sewage, the rapid removal of large quantities of deposit, and a number of operations which can be successfully carried out only with considerable system and under strict inspection. Operations of this kind should be as far as possible conducted at a distance from densely populated districts; and we consider it therefore a happy feature of the scheme adopted by the Board, that a small fraction only of the total amount of sewage requires to be manipulated in the immediate neighbourhood of London.

(Signed) A. W. Hofmann,
E. Frankland.

London, August 1859.

Appendix.

In the body of the report we have alluded to the considerable number of proposals addressed to the Metropolitan Board of Works, and referred by them to us for examination. In order to divest the report as much as possible of embarrassing detail, we have refrained from entering into a description of each of the several suggestions which have been made. We have however thought it desirable to give condensed abstracts of these proposals, in this Appendix.

Mr. John T. Barry proposes proto-sulphate of iron as a disinfectant for sewage, and also suggests that charcoal might be introduced into the air-spaces of sewers, in order to destroy noxious gases.

Mr. G. Lindsey Blyth recommends that superphosphate of magnesia should be mixed with the sewage, which should then be precipitated with lime, or another alkaline earth, the object being the production of a manure.

Mr. W. Burness recommends separate systems of drainage for sewage and for surface water. The latter he would filter, if necessary, before its discharge into the Thames; the sewage he would pump to the proper level, and pass through suitable pipes for distribution in the surrounding agricultural districts, completing the distribution before the sewage had time to putrefy and become offensive. He is of opinion that the value of liquid manure is much greater than that indicated by its constituents, because, "during the process of decomposition of animal and vegetable matter, oxygen is worked up both from water and the atmosphere; consequently hydrogen is liberated from the former, and nitrogen from the latter; so that these two uniting form ammonia, one of the best fertilisers."

Mr. Gurney Burt states that he will shortly make a proposal for utilizing the London sewage, without deodorization, by distributing it over the country by means of the railways.

Mr. Henry Callen recommends the deodorization of sewage by galvanic or electric agency.

Mr. John Chisholm makes a similar proposal.

Mr. Henry Bollman Condy calls attention to the manganates and permanganates as powerful agents of deodorization and disinfection.

Mr. Henry Cornfoot suggests ferruginous sulphate of alumina, commonly called Moll's Patent Reactive, as a deodorizer for sewage.

Mr. Daniel Dealey, chemist, and Mr. William Richards, engineer, propose to generate chlorine from "a mixture of muriatic acid and quick lime," on board a steamer, which is to be "constantly running up and down the river, and discharging the gas on both sides as it goes along."

Mr. Richard Dover advises to flush the sewers daily "with the antiseptic hydrochloric acid, and liquefied proto-sulphate of iron, and chloride of sodium combined."

Mr. C. F. Ellerman recalls attention to the use of perchloride of iron, which he proposed some years ago as a disinfectant.

Mr. Richard Ely intimates that he has a process for the precipitation of sewage in reservoirs, of which no further description was obtained.

Mr. F. A. Glassford proposes to carry off the rain-water in the sewers, and to make such arrangements in the houses as to allow only a limited quantity of water to become mixed with the excreta. This mixture is to be collected in vessels to be daily discharged into reservoirs, where it is to be mixed with sulphuric acid and allowed to settle. The liquor is to be then evaporated, and the solid matter squeezed through such filter-presses as are used at the Leicester Manure Works.

Mr. G. Garbert, of Mauritius, suggests the abolition of water-closets, and the substitution of boxes containing peat charcoal.

M. Gronvelle proposes to deodorize by means of a pyrito-aluminous lignite, commonly called "cendre noir," which is stated to be extensively used by the scavengers in Paris.

Mr. William Goreham communicates the following plan:—To form reservoirs at the mouths of the sewers; to allow the sewage to settle in these reservoirs; to remove the sediment by trays, and to disinfect and dry the contents of the latter by placing them in chambers through which the products of combustion of a suitable furnace are passing.

Mr. John Hitchman gives his arguments in favour of "The rainfall to the river,—the sewage to the land."

Mr. Howard, British Minister in Lisbon, reports on a contract between the municipality of that town and a company formed for collecting the excreta and converting them into sewage. The company propose to supply each house with a separating apparatus, and with the necessary disinfectant (the nature of which is not stated). The municipality will compel the inhabitants to use the apparatus, and propose to furnish the land for the works.

Mr. Henry Kemp suggests "pyritous peat" for deodorizing sewage. In a second communication Mr. Kemp enters into some details regarding the mode of applying the peat, which he proposes to inclose in wire cages attached to the sterns of the river steamers; and he advises the introduction of similar cages into the mouths of the sewers.

Mr. Charles F. Kirkman offers to exhibit upon a large scale the practicability of a plan which he has successfully employed upon a small scale. He does not state the nature of the plan in his original communication, but in a subsequent letter mentions that his method is not a chemical one.

Mr. James Knight proposes to establish a number of filter-beds on each side of the mouth of a sewer, and to allow only the clear water from which the solid matter has been deposited to flow into the Thames.

Mr. C. N. Kottula proposes to remove the Thames nuisance by increasing the specific gravity of the river over that of sea-water, "so that the river-water may become heavier than that of the sea; whereby the former, instead of being driven back by the incoming tide, will give way to the flow of the sea-water, and will allow it to flow up, while the river water will run out, or, at all events, remain under the sea-water." He thinks he can accomplish this object "by dosing into the river at various points common salt."

M. G. M. Legé suggests to attach to the drain of each house a receptacle so constructed as to allow of the separation of the liquids from the solids; the former to be permitted to pass into the sewers, and the latter being removed once in eight or ten days to be converted into manure.

M. Louis Napoleon Legras states, that he has invented a deodorizer which is applicable to London sewage water, and which produces a valuable manure. The nature of the agent is not stated, and no information could be obtained on application.

Digitized by Google

Mr. A. McDougall and Dr. Angus Smith propose the use of carbolate of lime in solution, and also of a solid mixture of sulphites and carbolates. These substances are to be added to the sewage to produce immediate and permanent deodorization.

Mr. F. C. Maguire advises to convey the sewage to railway stations, and then to transmit it to the surrounding agricultural districts through earthenware or iron pipes. If necessary and practicable, he would filter it through dry sewers constructed over the present drains, converting the solid matter into manure, and deodorizing the filtered liquid in subterraneous deodorizing docks; the deodorized fluid to be then pumped into reservoirs at levels sufficient to allow of its being conveyed in pipes along the various lines of railway to the provinces. He proposes no method of deodorization.

M. J. Marino, of Copenhagen, communicates a plan for inodorous water-closets.

Dr. Henry Medlock suggests that sewage would probably be deodorized by means of scrap iron, and subsequent filtration through beds of sand and charcoal; but he states that he has not yet had an opportunity of testing the efficacy of this suggestion on a sufficient scale and by a sufficient number of experiments.

Mr. George F. Morrell calls attention to the deodorizing properties of chloride of zinc.

The Rev. Henry Moule proposes to separate the sewage from the rainfall; the liquid portion of the former to be evaporated, the solid to be dried and deodorized. The ordinary modes of evaporating are stated to be chimerical, but the plan proposed is rendered perfectly possible "by the discovery in November last of something in the nature of steam which was hitherto unknown."

Mr. W. Oldham suggests to separate the solid filth from the sewage, and to distribute the liquid over the land in the vicinity.

M. Paulet, Fils, recommends the use of a mixture of sulphate oleate and chloride of zinc, and of sulphate of manganese, for the deodorization of sewage.

Mr. Rudolph Turecki states that he has discovered a material which enables him to disinfect excrementitious matters, and to convert them into manure; but he does not state the nature of the materials which he employs.

Mr. Wells is in possession of a method for the treatment of sewage, but states that it is not chemical, and is communicable only by personal interview.

Sir William Worsley suggests the conveyance of the sewage to a cesspool in the Greenwich Marshes, thence to flow into the river at the turn of tide. No method of deodorization is suggested.

A glance at these proposals will show at once how few of them address themselves to the special question submitted to us for inquiry. A final plan of disposing of the sewage having been fixed upon by the Board, our investigation was of necessity limited to a comparison of the efficiency of the several deodorizing agents proposed.

After experiments continued for several weeks, we arrived at the conclusions already stated in our report.

In these experiments we had occasion to observe, that most of the agents proposed possess the disinfecting power which their inventors have pointed out, and many of them in so marked a manner as to render them undoubtedly valuable for a variety of special purposes. Not one of them, however, in our opinion—with the exception of the agent suggested in the report—possesses that combination of properties which could warrant us in recommending it to the Metropolitan Board of Works for the deodorization of the London sewage.

RICKINGHALL INFERIOR, SUFFOLK.

The picturesque little village church at this place, which has been for some time undergoing a careful repair and restoration, was re-opened on the 18th of August. The edifice is particularly distinguished by the beauty of its south aisle, erected at the best period of the "decorated" age, and containing some unique windows of geometric pattern, and richly moulded both within and without. The tower is at the west end, and has the peculiarity—found only we believe in that part of England—of being *round*. Among the praiseworthy alterations just completed, and which are due, we believe, mainly to the exertions of the excellent rector, may be mentioned the underpinning of parts of the main walls, and the thorough repair of portions which had bulged, owing to the insufficiency of foundation, or the giving way of the materials themselves, which are chiefly flint;—the erection of new buttresses, &c. to the chancel, the clearing away of the old unsightly pews, gallery, and other fittings, and the re-modelling of the interior throughout. The new seats are of plain but good design, and without doors; the pulpit and desk also, with the chancel seats, which are of oak, exhibit the results of considerable study, harmonising exceedingly well with the rest of the work. The paving is of local tiles, except in the chancel, which has Minton's encaustic patterns. A new west window has been inserted in the tower, and filled with Powell's coloured glass; this being, among other features, specially presented to the church. The richly elaborated piscina in the south aisle is also in like manner to be restored forthwith.

NEW MILITARY HOSPITAL, NETLEY.

This building is situated about four miles south of Southampton, and a very short distance from the ruins of Netley Abbey. Near these ruins the road turns suddenly down to the edge of the sea and emerges upon a scene of activity of such magnitude and extent as to rival even the great works connected with the '51 edifice in Hyde Park. The hospital is upwards of a quarter of a mile in length from end to end, and is situated on a high and gently sloping bank of light gravelly soil, about 300 or 400 yards from high-water mark, and closed behind by a continuation of the hill, which is well and richly timbered. The building, in order to obtain the greatest amount of light and sunshine, runs due north and south. It is in the decorated Italian style, with purple bricks and Portland stone, the latter being used extensively. The whole structure consists of a massive and highly decorated centre, with two main wings, the latter being each of three stories, about 600 feet long and 70 high, with a light ornamental belfry tower on the northern and southern extremities. The centre is of four stories and 216 feet wide, with a dome-shaped campanile rising above it to the height of 150 feet. A noble portico of double columns of Portland stone gives a good effect, and materially adds to the imposing character of the whole design. The centre is intended mainly for the use of the officers connected with the hospital, and for the surgical and medical stores. In this part of the building, however, a large swimming bath, 57 feet long by 34 wide, is placed for the general use of the inmates, and near this is the library, of the same dimensions and 15 feet in height. In the vicinity of the swimming bath also are placed a range of bath-rooms only to be used medicinally, such as sulphur and acid baths, and which are quite distinct from the hot and cold baths at intervals throughout the building. The north and south wings are the portions of the hospital which will contain the great mass of the convalescents for whom it has been erected. Viewed from the outside these wings seem all windows; in the front of the building there are 200 windows 4 feet wide by 8 feet high. But the light and ventilation which are afforded by these appear on examination of the internal construction of the building to be far less than might be imagined from the outside. These windows do not open immediately upon the sick wards, but upon very long corridors of communication which run along the whole front of the building from end to end (more than a quarter of a mile), and into which corridors the wards lead. The arrangement is thus: on each floor of each wing are 12 wards; ten, being for the accommodation of nine patients each, are 36 feet long by 24 wide and 15 feet high, and two, as being meant for 16 men, are 48 feet long by 34 feet wide. There are thus 24 wards on the floors of both wings, and each wing has three floors. These wards, with out-wards in rear of the building, and some smaller ones in the centre wing, give accommodation in all for 1000 convalescents—a small number when it is considered that the building is almost the size of the Crystal Palace, and about six times the size of Guy's Hospital, which has always nearly 1000 sick within its walls. As we have already stated, a corridor of communication, 12 feet wide by 15 feet high, runs along each floor of the building from north to south. It is this corridor which has so many and such large windows in it, and it is this which gives access to the various wards which open into it.*

All the wrought-iron girders supporting the floors are hollow tubes, and are placed with their openings communicating with the air at the external walls. Pipes from these girders communicate with the base of all the wards and all the corridors, into

* See our remarks (page 333, vol. xxi.) upon the very defective provision made in this structure for light and ventilation.

Digitized by Google

which the air finds entry through perforated tiles just above the skirting of the floors. All the passages and all the corridors as well are made with arched ceilings, so that the foul and heated air may ascend and be carried off by the natural draught through the passage, and by ventilators in the ceiling contrived for the purpose, which communicate with the main flue of the building.

The number of baths and lavatories on the floors of each wing is so great as to be almost enough to accommodate half the patients at one time. A great improvement has been effected in having the kitchen and all the cooking offices entirely distinct and detached in the rear of the building, though communicating with it by covered windows. Over the kitchen are built two dining-rooms, each 60 feet long by 32 wide, where all the inmates who are well enough will assemble at meal hours, instead of, as under the system now pursued at most of our military hospitals, compelling each man to take his meal out of a little porringer, sitting either alone on the bed from which he has risen, or only surrounded by the other sick and diseased occupants of the ward. The chapel is, like the kitchen, detached from the main building, though connected with it in the same way. This is a lofty and capacious edifice, 100 feet long by 63 feet wide, and no less than 50 feet high. The interior will be simple, but very handsome and appropriate in its style of decoration, with two capacious galleries on the north and south sides, supported on very tasteful iron columns. In rear of all and quite detached are to be the orderly, store, guard, ablution, and *post mortem* rooms. Also detached in rear are ten separate wards of two stories each, and each ward being 40 feet long by 24 wide. Some of these will be set apart for convalescent officers, and others used for men recovering from cutaneous, feverish, or opthalmic disorders, whom it would not be prudent to allow to mix with the others while any fear of contagion remained. In rear of all was originally intended to be built a small guard-house, but it is now, it is said, to become a barrack, built to accommodate 600.

The building itself occupies 10 acres of ground, and the extent of ground around it, all of which will be converted into terrace gardens, is no less than 193 acres. All the drains are to meet in one main sewer, which carries it into the Solent beyond low-water mark. As far as regards the erection of the building itself, by the contractor, Mr. Myers, every portion of the work is of the very best and most durable kind. All the bricks are made and compressed on the works, and those used in the arches are formed entire in wedge-shaped lengths. The stone is, of course, of the best kind; the windows are to be of plate glass, and the window frames and sashes of mahogany. Altogether the whole edifice is of the most expensive and substantial description.

EXPERIMENTS WITH THE "HORIZONTAL FIRE TUBE" AND THE "MARTIN VERTICAL WATER TUBE" BOILERS.*

When the U.S. steam frigate San Jacinto returned to New York from her late three years' cruise in the East Indies and the China Sea, a survey was held on her old flue boilers, and their condition was found to be such that it was deemed judicious to replace them with new tubular ones. A convenient opportunity was thus furnished to make a test of the comparative evaporative efficiency of the two competitive kinds of tubular boiler, and the vessel was accordingly fitted by the Navy Department with one horizontal fire tube boiler, and one vertical water tube boiler; they have recently been experimented with by a Board of Chief Engineers, whose report is given below. It will be interesting to preface that report with a short description of the old boilers, in order that the results of the change may be correctly appreciated.

The old boilers were three in number, and of copper. They were of the double return drop flue type, and were placed in the vessel side by side with one chimney in common at the end opposite the furnaces. The fire room was 8½ feet wide, and extended athwartship.

Length of each boiler	25 ft. 6 in.
Breadth ,, ...	9 ,, 9 ,,
Height ,, (exclusive of steam chimney)	10 ,, 6 ,,
Number of furnaces in each boiler	2
Width of each furnace	4 ft. 2½ in.
Length of fire grates	7 ,, 9 ,,
Total grate surface in the 3 boilers	197·8 square feet
,, heating ,, ,, ...	5250· ,,
Aggregate cross area of the upper row of flues in 3 boilers	35·133 ,,
Aggregate cross area of the middle row of flues in 3 boilers	33·008 ,,
Aggregate cross area of the lower row of flues in 3 boilers	32·146 ,,
Cross area of the chimney	34·039 ,,
Height of the chimney above the grate bars ...	55 feet
Capacity of steam room in the 3 boilers ...	2440 cubic feet
Weight of the 3 boilers without chimney and grate bars	213,256 lb.
Weight of water in the 3 boilers at 12 inches above flues, and at 250° Fah.	121,200 ,,

With these boilers, during the last three years' cruise of the vessel in the East Indies and China Sea, there were obtained the following mean results, namely,

Number of pounds of Pennsylvania anthracite consumed per hour	2115·00
Number of pounds of Pennsylvania anthracite consumed per hour, per square foot of grate ...	10·69
Waste in ashes, clinker, and fine coal...	25 per cent.
Pounds of water evaporated per pound of anthracite from temperature of 100° Fah.	6·00
Pounds of water evaporated per pound of combustible from temperature of 100° Fah.	8·00

The economic evaporation by the new horizontal fire tube boiler, according to the experiments referred to, exceeds the above by 11⅛ per centum, making the comparison by weight of combustible; and by 11½ per centum, if it be made by weight of coal: while the evaporation by the vertical water tube boiler exceeds it by 31¾ per centum per unit of weight of combustible; and by 29⅛ per centum per unit of weight of coal.

By the change of boilers the ship carries, in the same space as originally allotted to the machinery and fuel, 40 tons more coal, increasing the quantity from 320 to 360 tons.

The aggregate weight of the original boilers and water was $149\frac{3}{10}$ tons; with the present boilers this weight is $115\frac{7}{10}$ tons.

It will be perceived that, while with the present boilers the aggregate weight of boilers, water, and fuel exceeds the aggregate weight of the original boilers, water, and fuel by only 6¾ tons, the time that the vessel can steam at the rate of 175 geographical miles per 24 hours, has been increased from 14 to 18 days.

The original boilers were about eight years old, and the middle and lower return flues and their connections, comprising about two-thirds of the total heating surface, were covered during the whole cruise with old scale varying from $\frac{1}{16}$ to ⅛ inch thick. This surface was inaccessible for scaling, and from the condition of the seams it would have been injudicious to have attempted it. No new scale was formed during the cruise, as the surface condenser operated satisfactorily.

Report.

"To the Secretary of the Navy.

Sir,—In obedience to your order of May 17th, 1859, the undersigned have experimented with the vertical water tube and the horizontal fire tube boilers on board the U.S. steamer San Jacinto, in the manner and for the purpose therein directed: and have the honour to submit the details of the experiments and their results in the following report.

Before giving an account of the manner of conducting the experiments, and the data obtained, it will be satisfactory to preface it with the following brief description of the boilers and engines employed.

Boilers.—The two boilers had precisely the same shell, both as regards form and dimensions. Also, the furnaces, ash-pits, doors, and smoke connections were precisely alike, and the grate bars were cast from the same pattern. The minimum calorimeter or area for draft through the tubes was likewise the same in both boilers; the fire grate surface employed was of the same area; and both boilers delivered in common into one smoke pipe, placed at the centre of their length, and immediately over the fire room. The boilers were situated in the vessel face to face, with a fire room 8½ feet wide between them, and extending in the direction of the vessel's length.

As regards dimensions, the only difference between the boilers was in the heating surface, which was considerably the greatest with the vertical water tube boiler.

As regards design, the only difference between the boilers was in the arrangement of the tubes, which in one was according to

* From the Journal of the Franklin Institute.

Digitized by Google

the type known as the English tubular or the horizontal fire tube boiler; while in the other it was according to the patent of Chief Engineer Daniel B. Martin, U.S.N., and is of the vertical water tube type.

In both boilers the relative positions of the tubes and furnaces are the same, the tubes being placed immediately over the furnaces: and in both boilers the tubes occupy sensibly the same space, namely, a length of 7 feet, a breadth of 3 feet, and a height with the horizontal fire tubes of 37 inches, and with the vertical water tubes of 33 inches; but this difference of 4 inches is compensated by the greater distance between the tubes and furnace crown indispensably necessary with the latter.

The comparative dimensions and weights of the boilers will be found in the following table:—

Dimensions and Weights of Boilers.

	English horizontal fire tube boiler.	Martin's vertical water tube boiler.
Width of boiler (fore and aft direction of the vessel) in feet and inches	21 3	21 3
Length of boiler (athwartships) at furnaces ...	10 6	10 6
Length of boiler (athwartships) extreme ...	11 6	11 6
Height of boiler, exclusive of steam chimney...	11 3	11 3
Height of boiler, inclusive of steam chimney...	13 3	13 3
Number of furnaces	6	6
Width of fire grate in each furnace in feet ...	3	3
Length of fire grate in each furnace in feet ...	6	6
Aggregate area of fire grate surface in square feet	108	108
Heating surface in the 6 furnaces, in square feet	289·20	289·20
,, ,, back smoke connection ,,	159·36	119·36
,, ,, front ,, ,,	136·40	106·40
,, ,, tubes measured on their exterior circumference in square feet	2282·67	2332·64
,, ,, tubes measured on their interior circumference in square feet	2078·92	2111·00
,, ,, sides, tops, and bottoms of the tube boxes in square feet	...	447·65
Total heating surface, the tube surface being measured on the exterior circumference in square feet	2867·63	3295·25
Total heating surface, the tube surface being measured on the interior circumference in square feet	2663·88	3073·61
Number of brass tubes...	414	1620
External diameter of the tubes in inches ...	3	2
Internal diameter of the tubes in inches ...	2·732	1·810
Length in inches of the tubes, extreme ...	84½	33
Thickness of metal of the tubes in inches ...	0·134	0·095
Weight of the tubes in pounds...	10115	9856
Calorimeter or area for direct draft through the tubes in square feet	16·854 } 16·854 }	16·889 front 21·555 back
Diameter of smoke pipe in feet and inches ...	6 4	6 4
Height of smoke pipe above fire grate in feet and inches	51 6	51 6
Steam room measured from 9 inches above top of tubes in cubic feet	735	776
Weight of water in boiler at 250° Fah., measured from 9 inches above top of tubes, in pounds...	46600	39200
Weight of boiler exclusive of water, grate bars, and valves, but inclusive of tubes, in pounds	86412	86860
Length occupied by the tubes in each boiler in inches	84½	84½
Height occupied by the tubes in each boiler in inches	37	33
Space between crown of furnace and bottom of tubes in inches	7	9

Engines.—The engines are geared, and the cylinder valves are of the usual double poppet kind. The steam is cut off by the steam valve with the adjustable arrangement patented by Allen and Wells. The two cylinders are connected upon the driving shaft at right angles to each other; and they have in common one surface condenser constructed according to the patent of J. P. Pirsson.

The following are the dimensions required to be known in connection with the experiments, namely,

Diameter of the forward cylinder	70½ inches
,, after ,, ...	70¾ ,,
Stroke of piston of both engines...	4 feet
Aggregate area of both pistons	7752 square inches
Space displacement of the pistons of both engines per stroke	215·33 cubic feet
Space comprised between pistons and cut off valves at one end of both cylinders... ...	9·61 ,,
Total space filled with steam of the final cylinder pressure, per stroke of both pistons	225·94 ,,

Mode of conducting experiments.—The experiments were made to determine the *relative* evaporative efficiencies of the two boilers under the conditions of actual practice on board marine steamers. For this purpose a short experiment would be valueless, from the impossibility of knowing whether the condition of the fires was exactly the same at the commencement and at the end—from the inequality in firing—from the different proportions of refuse found even in different shovelfulls from the same heap of coals—from fluctuations in the draft—from the losses by cleaning the furnaces—and from the different quantities of air in proportion to fuel admitted at different times. It was, therefore, considered necessary that the experiments with each boiler should continue uninterruptedly four days or ninety-six hours. The weight of water evaporated was to be ascertained from the steam pressure in the cylinder at the end of the stroke of piston as given by the indicator. The cost of this evaporation was the weight of combustible consumed; by combustible is meant the remainder of the coal after deducting the refuse withdrawn from the furnaces as ashes, clinker, and fine coal.

The evaporation as thus determined, though relatively correct, is not absolutely so; because it is exclusive of the steam condensed in the boiler, in the steam pipes, in the cylinders, &c., and of the loss of heat by priming and leakage; but on the other hand, the evaporation measured by water in a tank previous to its entering the boiler would also be incorrect, from the loss by priming and from leakage. The tank measurement gives too great an evaporation, the indicator measurement too small a one; but the latter is the most useful practically, because the most convenient and habitually employed; in effect, it is only comparative results that could be obtained in either case, and they are all that are practically needed.

The experiments were conducted in precisely the same manner with both boilers, and as follows, namely:—At the commencement no account was taken of the coal required to raise steam, or of the temperature of the water in the boilers; but after steam was raised to 22 lb. per square inch pressure above the atmosphere, the level of the water in the boilers was noted, the condition of the fires estimated as nearly as possible by the eye, and the engines started. At the end of each experiment, the water in the boiler and the condition of the fires were left as at the commencement. The experiments with both boilers were begun and ended at mid-day, and continued uninterruptedly ninety-six hours. During that time the boiler steam pressure and the vacuum in the condenser by barometer guages were noted every fifteen minutes, and at the close of each hour there was recorded for that hour the mean steam pressure, vacuum, temperature of engine and fire-rooms, of the salt and fresh water hot-wells, and of the injection water; also the weight of coal thrown into the furnaces, and the weight of dry refuse in ashes, clinkers, and fine coal withdrawn. Each hour an indicator double diagram was taken from both cylinders, and from the mean of the final pressures as given by these diagrams the evaporation was calculated. Owing to excessive condensation in the cylinders and the continual discharge by their relief valves of the resulting fresh water, the surface condenser gave a deficit of one-sixth, that is to say, it returned to the boiler as distilled water five-sixths of the steam leaving it. At the commencement of each experiment the boiler was filled with sea water, and at the expiration of every hour the saturation was recorded, and also the number of inches in depth of water blown off to maintain it at 1½ times the natural concentration. Every pound of the coal and refuse was carefully weighed by a steelyard. The number of double strokes made by the piston was taken by a self-registering counter. The indicators were excellent instruments, and every precaution was taken to insure exact similarity of circumstance with both boilers. The cut-offs, set to cut off the steam in the cylinders at $\frac{48}{100}$ of the stroke of piston from the commencement, were secured to prevent accidental alteration. The throttle (a butterfly valve) was kept unchanged at two holes open, eight holes being wide open. The

Digitized by Google

same fireman fired both boilers, and the same assistant engineers directed them.

The experiments were first made on the horizontal fire tube boiler; they were begun at noon on the 10th of June, and after being completed the steam was shut off from it and let on from the vertical water tube boiler, without stopping the engines. The piston and cylinder valves of both engines on being tried at the termination of the experiments, noon June 18th, exhibited no sensible amount of leakage.

The coal used was hard Pennsylvania anthracite of very indifferent quality, giving for a mean, with slow combustion and careful firing, the excessive amount of over 25 per centum of dry refuse.

In the following table will be found the complete data and results of the experiments.

Data and Results of Experiments.

Data.	English horizontal fire tube boiler.	Martin's vertical water tube boiler.
Duration of experiments in consecutive hours...	96	96
Total number of double strokes of piston made by the engines per counter	62518	64196
Mean number of double strokes of piston made per minute by engines	10·854	11·145
Mean pressure of steam in boiler in pounds per square inch above atmosphere	10·43	11·41
Mean vacuum in condenser in inches of mercury per barometer guage	21·48	20·80
Total number of pounds of anthracite consumed	100436·00	92512·00
,, ,, refuse in ashes, clinkers, and fine coal ...	24908·00	24178·00
,, ,, combustible consumed	75528·00	68334·00
Per centum of the anthracite in refuse ...	24·80	26·14
Mean pressure above zero, per indicator, in pounds per square inch, of the steam in cylinders at commencement of stroke... ...	19·44	10·40
Mean pressure above zero, per indicator, in pounds per square inch, of the steam in cylinders at point of cutting off	16·40	17·20
Mean pressure above zero, per indicator, in pounds per square inch, of the steam at end of stroke of piston	9·11	9·50
Mean gross effective pressure on pistons in pounds per square inch, per indicator ...	9·18	9·63
Mean back pressure above zero against pistons in pounds per square inch, per indicator ...	5·50	5·75
Mean gross horse power developed by the engines	187·25	201·696
Mean number of pounds of anthracite consumed per hour	1046·21	963·67
Mean number of pounds of anthracite consumed per hour, per square foot of grate ...	9·687	8·923
Mean temperature in degrees Fah. of engine room	96	106
,, ,, on deck	61	74
,, ,, of the fire room ...	99	112
,, ,, salt water hot-well	100	102
,, ,, fresh ,,	100	100
,, ,, injection water ...	62	65
Total number of pounds of water blown out of boiler to keep the saturation at $\frac{1\frac{1}{4}}{32}$	68424	123144
Results.		
Number of pounds of water evaporated from feed water temperature of 100° Fah., calculated from the steam pressure in cylinder at end of stroke	663629·007	705463·426
Number of pounds of water evaporated from feed water temperature of 100° Fah., due to the weight of boiler water blown off ...	8183·448	14857·488
Total number of pounds of water evaporated from feed water temperature of 100° Fah. ...	671813·455	720625·914
Pounds of water evaporated from feed water temperature of 100° Fah. by 1 lb. of anthracite	6·689	7·786
Ditto by 1 lb. of combustible	8·895	10·541

Comparative advantages and disadvantages.—We are directed by your order to report to the department the relative advantages and disadvantages of the two kinds of boiler as regards space occupied, weight, cost, accessibility for cleaning and repairs, durability, evaporative efficiency, and the relative quantities of steam that can be furnished in equal times.

1. *As regards space.*—In the particular specimens experimented on, the space occupied by both types of boiler was equal; but not so the area of contained heating surface. If the proper measure of that surface be, as we think it is, the extent exposed to the reception of heat from the products of combustion, then the heating surface in the vertical water tube boiler exceeded that in the horizontal fire tube boiler by nearly 23¾ per centum of the latter. If, however, it be measured by the extent from which water is evaporated, then the superiority will still remain with the vertical water tube boiler, but reduced to 7½ per centum.

2. *As regards the weights of the two boilers.*—By referring to the table of their dimensions and weights it will be seen that in this respect the experimental boilers were nearly equal, the horizontal fire tube having a slight advantage in lightness; but if the aggregate weight of boiler and contained water at a steaming level be compared, then the vertical water tube has a superiority of nearly 5¼ per centum over its competitor.

3. *Cost.*—In this particular the horizontal fire tube boiler is slightly the cheapest, but the difference is unimportant.

4. *Accessibility for cleaning and repairs.*—For the removal of scale or any insoluble sediment on the water surfaces of the tubes, the vertical water tube boiler has a decisive superiority, from the complete and easy manner in which the entire of those surfaces can be reached by a scaling tool and cleaned mechanically. With the horizontal fire tube boiler this operation is very tedious and difficult, and at the best is only partial. It may indeed be said, that the whole of the horizontal tubes cannot be scaled without the removal of a portion of them; and from the fact of their becoming more and more coated with scale as their age increases, their evaporative efficiency will be continuously impaired to the extent of the loss of heat thus intercepted. On the other hand, the horizontal fire tubes are much more easily and completely swept of soot and deposit from the furnaces; they are also more easily plugged when leaking. Furthermore, they are only about one-fourth the number of the vertical water tubes, and the liability to leakage is correspondingly lessened, but this liability is so trifling as to be of no value in a practical estimate. The remaining portions of both boilers are equally accessible for cleaning and repairs.

5. *Durability.*—We have no data on which to base an opinion in this respect, but we believe both boilers to be about equal.

6. *Evaporative efficiency.*—The relative evaporative efficiency as given by the experiments applies rigorously only to the particular specimens of the types of boiler employed, with their peculiarities of proportion, and under the conditions of the trials. Under other conditions, and with other proportions, the relative evaporative efficiency would doubtless be different, and in direction as determined by better or worse proportions, and by conditions more or less favourable for one kind of boiler over the other. The proportions given to both boilers in the present case, however, are such as are now generally approved in practice.

With these proportions, and under the actual conditions of the trials, the evaporative efficiency of the vertical water tube boiler exceeds that of the horizontal fire tube by 18½ per centum of the evaporation of the latter, making the comparison by weight of the combustible consumed; and by 16¾ per centum if the comparison be made by weight of coal consumed. The former is, of course, the proper result.

7. *Relative quantities of steam that can be furnished in equal times by the two boilers.*—In this respect the superiority remains with the horizontal fire tube boiler in which the combustion of the fuel can be forced to a considerably greater extent than in the vertical water tube boiler. The additional steam, however, thus obtained will be at a greater *pro rata* cost of coal; but we have no data to determine either the increased quantity or its increased cost.

Finally, in view of the much greater evaporative efficiency of the vertical water tube boiler, and of the facility and completeness with which it may be scaled—the two qualities of paramount importance with marine boilers—we would express our decided opinion that its superiority over the horizontal fire tube boiler is so strongly marked as to unquestionably entitle it to the preference.

B. F. Isherwood, Wm. E. Everett,
James W. King, John Faron,
Chief Engineers, U.S.N."

Digitized by Google

ATLANTIC TELEGRAPH CABLE.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—Since you inserted my observations on the Atlantic telegraph cable in your number for August last, there has been a great debate respecting the durability of marine telegraph cables, and if the opinion of Mr. R. Stephenson and those who think with him be correct, "that the cable will not last at the most more than 10 or 12 years," no amount of traffic could repay the expense of such frequent renewals of the cable as would in that case be required, so that unless some means can be devised to increase the durability of the cable, oceanic telegraphic communication must soon cease to exist. A remedy for the evil might perhaps be fully entitled to a patent, but without reference to patent right, I beg to offer a plan for giving to the india-rubber or gutta-percha such antiseptic properties as will prolong their duration from 10 or 12 years to at least 50 or 60 years. What I propose is, the mixing of creosote or some other strong antiseptic with the india-rubber or gutta-percha whilst in a state of solution. Creosote and other antiseptics have caused wood for railway sleepers to last five or six times as long as they did before its application, and as the antiseptic could only be applied through the pores of the wood in the solid state, it can of course be more intimately mixed and blended with any material whilst in a state of solution, and its antiseptic effects ought to be so much the greater. As the durability of the wood is rendered five or six times greater than before, the antiseptic ought to do as much or more for the material of the cable, and make its minimum instead of maximum duration 50 or 60 years instead of 10 or 12, and thus enable the company easily to create a sufficient reserved fund to pay for the renewal of the cable when such renewal should be eventually required.

I before alluded to spun glass as an isolator; glass might also be applied by threading the wire with glass beads, which might be easily done. If glass was thought too costly, or too difficult in its application, silk as the next best isolator, and one more easily applied, might be used instead of glass. In either case the glass or silk would require an additional covering of india-rubber or gutta-percha, as a protection from the sea water, but if the improved isolator rendered the indications of the electric current more certain or more clear and distinct, it might be well worth the additional expense.—I remain, &c.

THOMAS BRAMLEY.

September 8, 1859.

AN APPARATUS FOR SEEING THROUGH TUBULAR DRAINS FROM THE SURFACE OF THE STREET.*

By JAMES LESLIE, C.E., F.R.S.E.

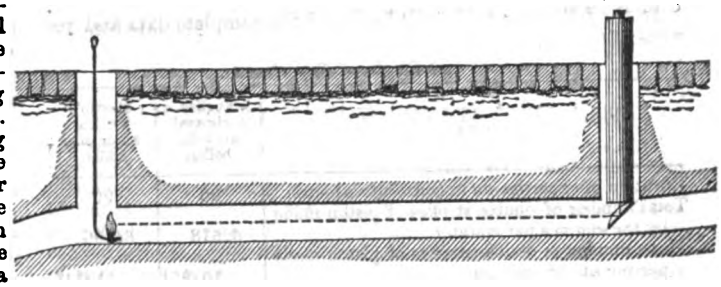
ALTHOUGH by no means an advocate for the general use of tubular main drains for towns, being of opinion that always, except under some special circumstances, street drains of any considerable depth ought to be of such dimensions as that a person may pass through them to inspect, clean, or repair them,—I am nevertheless aware that cases do not unfrequently occur where, from the sake of economy or other reasons, recourse must of necessity be had to pipes, instead of to large built drains.

It is therefore desirable, without reference to the keen controversy which has been carried on as to the respective merits of built drains or of tubes, that means should be provided for seeing through tubular drains when they are used, so as to be able to ascertain whether there be any sediment or obstruction in them, and if there be, to be able to judge of its position and extent, before taking measures for its removal.

This has been accomplished by the engineers of the Board of Health very effectually, by having at every change of direction or of gradient of the drain, alternately a chamber or manhole, and a vertical pipe down from the surface of the street, by means of which latter a lamp or candle can be lowered down to the axis of the drain, when if there be any obstruction it can be seen by a person looking from the bottom of the nearest manhole.

The manholes, however, must cost a considerable sum more than the lampholes, and that led me to suggest a method by which vertical pipes may be employed for seeing from, as well as for lowering the light down through.

That I propose to do by having a piece of mirror set at an angle of 45° at the end of a tube, made in short lengths, so as to be capable of being coupled together, the whole length being sufficient to reach down to the bottom of the deepest drain. This tube, with the mirror at the lower end, is to be lowered down into the drain, and so a person looking down through it from the street may, with the help of an opera-glass or telescope of small power, see the light lowered down the next vertical pipe or lamphole, almost as clearly as by going down into the chamber or manhole, and certainly in a much more cleanly fashion. In this way the drains may be inspected by parties who might be very reluctant to go down into the dirty underground chambers.



The drain-pipes must of course be formed in straight lines between each two vertical pipes, so as to be capable of being seen through.

The tube now exhibited, which is only 3 inches diameter, may be considered merely as a model, as I would have the apparatus, if applied to use, made of double that diameter; so as to quadruple the area of the mirror.

It had, when made about two years ago, a plain glass outside of the mirror to keep the latter from being dirtied, with a hole above for the hand to wipe the mirror when necessary; but the plain glass was afterwards taken out, and I am undecided as to whether it be better to have it in or not.

The apparatus was recommended to the commissioners of police of Edinburgh, in a report by Mr. Jardine and me on the Old Town drainage, about a year and a half ago, to be used in the drains of the closes, which in many cases almost of necessity required to be tubular; but I am not aware that it has ever been actually applied to practice, though I saw by the newspapers that something of the sort had been used for looking out of the trenches before Sebastopol.

It must not of course be supposed that any merit of originality is claimed for this simple adaptation to a useful purpose of a principle so well known as to have been long used in the construction of many optical instruments, and even in that of an old-fashioned toy.

* Paper read at the Royal Scottish Society of Arts.

THE CITY CHURCHES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—Any observant person who passes over the metropolitan bridges will perceive that the glorious dome of St. Paul's Cathedral, and the towers and spires of the City churches grouped around it, like so many attendant satellites surrounding their central planet, are the great features which give any architectural beauty and effect to what would otherwise be an immense chaotic mass of brick and mortar ugliness. Certainly any person of taste will see that these towers and spires are of great importance as a matter of artistic effect. Such being the case, it is evident that a project which has been several times broached (and it must be admitted, not wholly without reason) for the removal of most of these towers and spires, is much to be deprecated, and ought to be opposed if it is to deprive us of these oases in our dreary wilderness of houses and buildings.

But if it can be shown, as I think it can, that all the good that could be effected by removal of the City churches might be got without removing these towers and spires, which form such a pleasing relief to the monotonous character of the metropolis, then it will become highly culpable to let these architectural advantages be taken away from us.

Now what is wanted seems to be, that as a great number of the City churches have no congregations, they should be removed to other parts of the metropolis, where congregations would soon fill them. For this the spires are not wanted, but the churches; —let then the towers and spires remain, but take the churches

Digitized by Google

away, if you please. And in doing so, it may be as well to call to mind that the lower part of these towers would be useful for fire engine houses, stations for fire escapes, and for various parochial uses. Indeed many of them are even now rendered useful in this way.

And the churches, if removed, could have a small bell turret, which would be quite equal to what any neighbourhood where these churches ought to be put up again have any right to expect. For if any neighbourhood requires a handsome church and tower all complete, let them build a new one.

In cases where this separation between the tower and church cannot be effected, then I say, let both church and tower remain.

MEGALOPOLIS.

THE NEW WATER-WORKS AT OLDHAM.

THE Act of Parliament for the construction of these water-works was obtained in 1855. The scheme consisted of two parts, distinct from each other. One was the gathering of water from the surface of Besom Hill and the parts adjoining, in order to conduct it to the reservoirs at the old water-works in Strinesdale, by means of a conduit 4 miles in length. In order to carry out this part of the plan it was necessary to construct the reservoir at Brushes Clough and Besom Hill, the object of which is to guarantee a specific supply of water to the millowners who had previously been dependent upon the streams rising in that locality. These reservoirs are now complete and the conduit in operation, so that all the water beyond what is necessary to compensate the millowners is conducted to the Strinesdale reservoirs. This part of the undertaking has cost about £30,000. The estimated cost of the new works at Piethorn Clough, which form the main portion of the new scheme, will of course be far greater than the sum necessary for the completion of the undertaking at Brushes Clough and Besom Hill, and the borrowing powers of the corporation, as fixed by the Act, extend to a further sum of £110,000, making £140,000 in all, an amount which in all probability will suffice for the completion of the work.

The locality chosen for the construction of the new water-works is the best that could have been found in the neighbourhood. The water is good, and the supply abundant, and as Oldham is an elevated town—some portions of it that will have to be supplied by water being nearly 800 feet above the level of the sea—no other place in the neighbourhood would have been suitable to construct water-works of such magnitude as the present and prospective wants of the town require. The cost of the land necessary for the construction of the reservoirs is about £14,000.

The gathering ground for the new reservoirs comprises 1350 acres, of which 1240 acres may be termed the natural gathering ground, the rest—about 110 acres—having been rendered available by the construction of a feeder running along the hill side to the principal reservoir from a place called Doldrum. The gathering ground reaches to the watersheddings which divide the counties of Lancashire and Yorkshire—the highest point being 1500 feet above the level of the sea. There are four reservoirs in the course of construction in the Piethorn valley. The water will ordinarily be admitted into the top reservoir; but when not required, owing to there being a sufficiency of water in the reservoirs already, or when rendered muddy during one of the sudden floods which sometimes occur, it will be conducted along the byewash, which commences above the top water mark, the whole length of the reservoirs to the lowest or compensation reservoir. The top reservoir will at the same time act as a purifier for the main reservoir, from which the supply for the town will be drawn. This reservoir is long and narrow, and tapers to a point at the top part where the Piethorn stream enters it. It will be about 740 yards long, and the breadth of the embankment about 240 yards. The embankment will be 320 feet broad at the bottom, and will gradually taper until it will be 30 feet at the top—there being a 3-feet puddle wall in the centre. It will contain upwards of 76,000 cubic yards of earth. The surface area of the reservoir will be 11 acres. The extreme depth of the water in this reservoir will be 60 feet, and will contain 7,000,000 cubic feet of water, so that it is calculated to hold nearly 44,000,000 gallons. The water will be drawn off by means of iron pipes 18 inches in diameter, and before passing into the large reservoir it will pass through another small lodge, where the work of purification will be completed. This reservoir will be a very small wreck lodge, and between it and the main reservoir the public highway, which has been diverted from the bed of the middle reservoir, will pass.

The main reservoir for the supply of Oldham will be 800 yards long and 400 in extreme breadth. It will cover 40 acres when full of water, and will then contain 52,720 cubic feet, or 333,000,000 gallons of water. It will be 80 feet deep, and of this 65 feet will be available for the water to be drawn off for use. The embankment will be 1040 feet across from one side to the other, and at the bottom it is 420 feet broad, tapering to the top, where it is to be 32 feet broad. The top water surface of the large reservoir will be of just the same level as the upper reservoir in Strinesdale, so that the water can be run from the Piethorn Waterworks to those in Strinesdale, as both are connected by the same mains: each is 830 feet above the level of the sea. The water will be drawn off through a substantially-constructed stone culvert running under the embankment, of 4 feet diameter, containing two iron pipes, one to supply the mains for the town, and the other to draw water off into the compensation reservoir, which is situated below the main reservoir. The pipes for the former purpose are 20 inches in diameter, and those for the latter 12 inches inside. These pipes are embedded in a solid mass of masonry at the end of the culvert, and the supply-pipe for the town is to be continued up the slope of the embankment, at the top of which there will be the machinery necessary for opening and shutting off the water. At certain distances along the sloping pipe there will be valves, constructed so that the water can be drawn off at different levels, which will insure a pure supply, as the clearest water will be at the top, and the least valuable portion (which will run into the compensation reservoir below) at the bottom.

The compensation reservoir is the lowest of all. In the centre part of the embankment there is a natural hill, which saves expense in the formation of the embankment, provided there are no crevices for the water to escape in it. From this hill embankments are in the course of construction to the sides of the reservoir, and are in a forward state already. The embankments will contain 450,636 cubic yards of earth; the surface area of the reservoir will be 12 acres, and it will contain 10,333,535 cubic feet, or nearly 63,000,000 gallons of water. In order to compensate the millowners for the water taken from them, they will thus receive a regular supply of 219 cubic feet per minute during twelve hours of the day for six days in the week. To insure the exact supply from the compensation reservoir, the water will be kept in a cistern at the uniform height of 4 feet by means of a valve and ball-tap, otherwise the water given out would necessarily vary with the pressure from the varying height of water in the reservoir. Economy, as well as a regular supply, will thus be obtained by the simplest means.

The work at present going on consists principally of the formation of the embankments and the culvert.

The streams which empty themselves into the new water-works give a large supply of water, even in years when the minimum amount of water falls. The principal is the Piethorn stream, which rises on Bleaked-gate moor, at an elevation of 1400 feet above the sea level, and empties itself into the top reservoir, as before stated. Another is the Coldgreave stream, which rises on Foxstone Edge, above the Oldham and Ripponden turnpike road, which it crosses in its course to the main reservoir, where it enters between the Norman Hill farm and the Coldgreave farm. This stream rises at an elevation of nearly 1500 feet. The Hanging Lees stream also falls into the middle reservoir, and rises above the Rooding farm, at an elevation of 1000 feet. The Tom Clough stream rises on Ogden Edge also at an elevation of 1000 feet above the sea level, and falls into the middle reservoir. On the other side of the reservoir there is one stream which rises between Rhodes' Barn and Binns' Barn farms at the same elevation, and another one, known as the Raghole stream, rises near Doldrum, at an elevation of 896 feet. It is conducted by the feeder along the hill side to the middle reservoir.

TAYLERSON'S DIAGONAL PRINCIPLE OF IRON SHIP BUILDING.

By R. TAYLERSON.*

(*With an Engraving.*)

ON looking at an iron ship of the ordinary construction standing in frame (see Plate, Fig. 1) it will appear that the frames without the plates offer no resistance to any force tending to tear the ship asunder in the direction of its vertical planes. The frames are placed vertically, and parallel to each other; and instead of giving strength to the structure, they absolutely require the attachment of the outside plates to keep them in their places. These frames are secured to the outside skin by rivets, in a direct vertical line from the gunwale to the keel on each side of the ship, thus presenting a series of lines of weakness, owing to the displacement of iron to make the rivet holes necessary for attaching the outside plates, just as is familiarly illustrated in the perforations in a sheet of postage stamps.

This weakness, it is manifest, springs from two causes: First, the frames being in a vertical direction and parallel to each other cannot offer sufficient resistance to any force or strain having a tendency to tear the ship asunder transversely. Secondly, the frames being secured, as I have stated, to the outside shell by rivets running in a direct vertical line from the gunwale to the keel, they entail one continuous line of weakness in that direction.

Being thoroughly satisfied that there was a radical defect and an inherent weakness in this mode of construction, and reading of many accidents, resulting in a deplorable loss of life and property, attributable to and occasioned by this weakness alone,—

* From a Paper read before the United Service Institution, February 21, 1859.

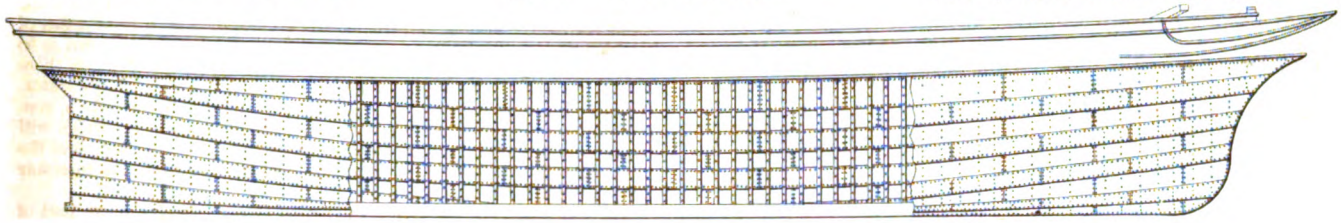
Digitized by Google

TAYLERSON'S PATENTED DIAGONAL PRINCIPLE OF IRON SHIP BUILDING

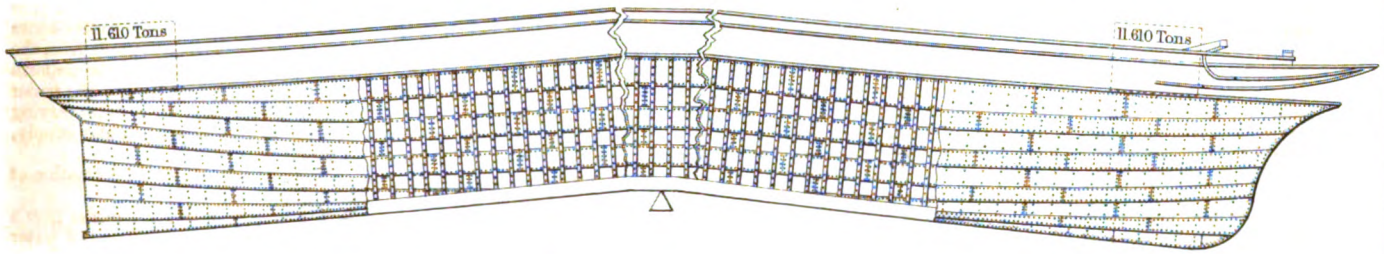
Nº 2
Shewing the plating of an Iron Ship on the present mode of construction

Nº 1
Shewing an Iron Ship in frame on the present mode of construction

Nº 3.
Shewing the plating of an Iron Ship on the present mode of construction



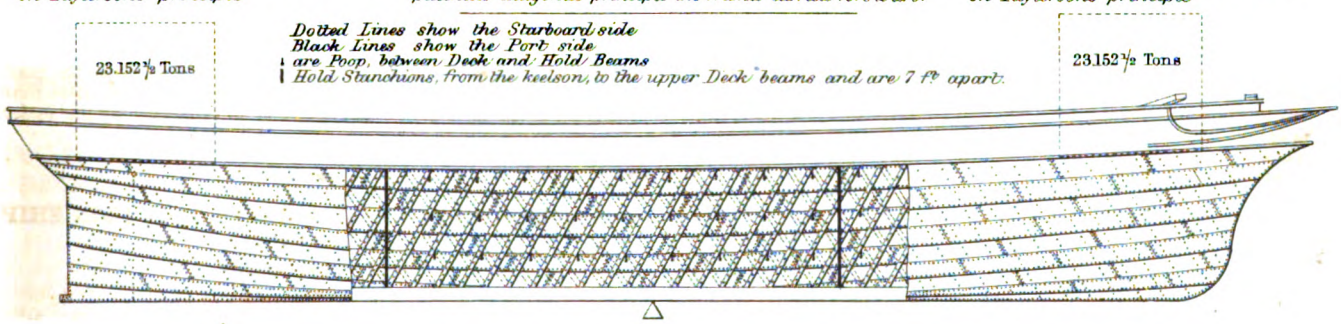
Shewing an Iron Ship on the Vertical Principal, breaking her back by the Strain upon her.



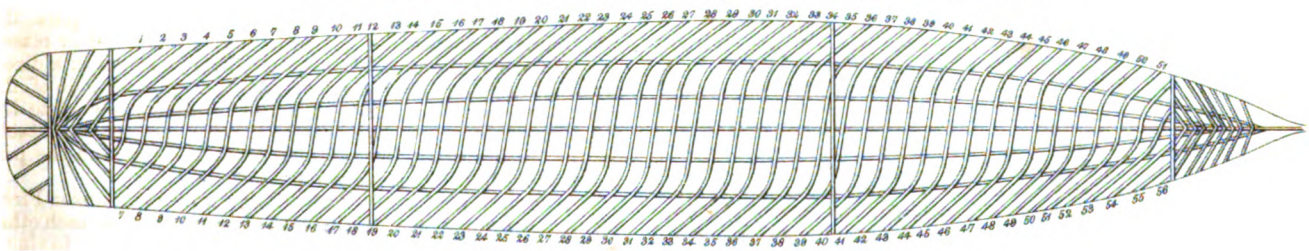
Nº 5.
Shewing the side of the Ship plated on Taylersons principle

Nº 4.
Shewing the side of a Ship in frame on Taylerson's patented diagonal principle the frames carried fore & aft.

Nº 6.
Shewing the side of the Ship plated on Taylersons principle



Nº 7.
Shewing the frames inside of a Ship built on Taylerson's patented diagonal principle



J.R.Johbins.

Digitized by Google

Digitized by Google

the ships, to use the uniform language of these painful narrations, "breaking their backs," or in other words breaking in two parts, from the gunwale to the keel,—I conceived the idea of the diagonal principle, which I shall now proceed to lay before you.

My proposition, in relation to my diagonal method, is this, namely, that in the case of the vertical principle just now detailed, the line of resistance to any force acting in the direction of the vertical planes of the ship will be in a line with the shortest circumferential line of the body of the ship, thereby opposing the least amount of resistance to fracture coming in the direction of these planes; whereas, in the case of a ship built in accordance with my diagonal principle, the line of resistance to forces acting in the direction of these vertical planes will be diagonal to the circumferential line of the body of the ship, thereby opposing the greatest amount of resistance that can be given at an angle equivalent to the inclination of the frames.

The same argument and the same reasoning apply to the perforations in the plates, or outside skin, which, running in the same vertical line with the frames, as already described, produce a series of lines of inherent weakness in the structure of the ship, and which I propose to remedy by my patented mode of making the line of junction of the butts of the plates diagonal instead of vertical, as in the present mode of construction.

The next branch of my patent, to which I would beg to call attention, is my hollow girder keel and keelson.

At present iron ships are built upon a solid rectangular bar of iron. It would appear pretty evident that the keel, mechanically speaking, should answer the double purpose of a base on which the frames are to rest, and from which the outside plates spring, and also a foundation of strength to the whole structure; and the question naturally arises for our inquiry, is this solid rectangular bar the best and the strongest that we can supply to meet the requirements of this double purpose? It appears to me that it is not, and that the hollow girder keel and keelson combined will give an increase in point of stability of about 40 per cent. beyond that of the rectangular bar, and this is long since established as an accomplished fact. It is well known that the solid rectangular bar of iron has very little power of bearing a load or resisting a transverse strain, and that if it were placed on its edge on props at the extreme ends it could hardly sustain its own weight, but that laid flat, and kept in its place by side attachments, as in the hollow girder keel and keelson combined, which I propose in its stead, its strength would be augmented, owing to its increased area, to resist transverse strain not less than from 30 to 40 per cent.; and this is the principle so beautifully exemplified in that magnificent model structure—the tubular-bridge which spans the Menai Straits.

Another part of my mode of building iron ships in connection with my diagonal frames, of more than ordinary moment, which with the public has done more to establish confidence in the safety of iron ships than any other quality which they possess, is the adoption of watertight bulkheads; but although bulkheads under the present mode of construction are said to be watertight, they are not so in reality, because were the angle-iron frames from which they spring so closely riveted as would be necessary under the pressure of a column of water, say 18 feet (the load immersion of most of our large steamers), the frame to which the bulkhead is secured would be nearly cut in two by the displacement of iron to form the rivet holes, whilst by the mode adopted by me the rivets may be put from 6 to 9 inches apart, and yet make a complete watertight compartment in the ship.

I will now give the structural details of the ship now building by me at my works at Port Glasgow, and ask particular attention to two cardinal points or features of structural stability not to be found in any other ship that has yet been built.

The frames or ribs of this ship, which constitute the main support of the ship, run in an oblique direction from the starboard gunwale down the side and across the keel, to which they are firmly united by an intercostal keelson and four sister keelsons, these continuing their obliquity up the opposite side to the larboard gunwale. The poop and forecastle beams are secured to one frame on the starboard side, and to a different frame on the port side. The main deck beams are also fixed to different frames, and also the lower deck beam; that is, the end of the main deck beam is secured to one frame on the starboard side running forward, and to a perfectly different frame on the port side running aft, which frames, being placed diagonally reverse to each other, are 28 feet apart at the gunwale, but joined together at the keel, by which means almost every beam is fastened to a frame, and the floors are likewise fastened to the frames, so that the ship forms a complete network of iron, embracing diagonal and vertical combinations of structural stability amounting to double that of the present mode of building iron ships. Before this ship can break in two parts or tear her plates asunder, she must break through 20 frames of angle-iron 4½ inches by 3 by ½-inch, as well as 10 frames of angle-iron 3 inches by 3 by $\frac{7}{16}$-inch; whereas in a ship built on the vertical principle the poop and main and lower deck beams are secured to one frame only on the starboard and port sides, and they are three feet apart at least, which leaves every alternate frame unsustained by any beam at all, so that on the application of any force to produce a rupture in a vertical line there is not a single frame interposing to resist the rupture from the keel to the gunwale. The outside plates are $\frac{11}{16}$-inch and $\frac{3}{4}$-inch thick in all parts when so required by Lloyds'. She is divided vertically by four watertight bulkheads half an inch in thickness, and these are strengthened by diagonal stays or bars; and, having a deck of iron besides one of timber, she is, so to speak, a hollow tubular girder similar to the Britannia Bridge, with this exception, of course, that the bridge is a flat structure, whilst the bottom of this ship is an inverted arch, which is acknowledged to be a necessary form for the bottom of a ship.

Let us now turn our attention to the experiment, made with the most scrupulous fidelity, to test the strength of this diagonal principle so adopted by me.

Two models were constructed for this purpose, one to represent the present vertical mode of building, and the other to represent my patented diagonal principle. In all other respects the models were precisely similar, each having an elastic keel to admit of a proper distribution of the strain, which in this experiment was obtained by placing weights on the ends, whilst each structure rested on a fulcrum intended to indicate the position of a rock or sand-bank under its keel. The result of this experiment proved that, whilst a ship built according to the ordinary plan would be torn asunder vertically through her plating, or, as the phrase is, "break her back," and break in two, a ship built on my patented diagonal principle would resist a strain from *more than double the amount of force without any injurious effect whatever;* and, in the experiment referred to, the model representation of the principle was not even twisted by the great amount of strain upon it. (See Mr. Thornton's Report appended.)

Discussion.

Mr. SMITH.—I think Mr. Taylerson has brought before the meeting an exceedingly ingenious and meritorious system of construction of iron ships. The matter is deserving the best attention of naval architects, and those who are interested in the employment of iron ships. I think, however, that the statement of Mr. Taylerson with respect to what he assumes as the defects of the present system of iron construction should not pass without some observation from me, I do not agree with him that, because the ribs of an iron ship of the ordinary construction spring from the keel at right angles thereto, and form a curve of the smallest circumference, that therefore the ship is of a very weak form. I am quite prepared to admit that too little regard is paid to the construction of the keel and of that which should form the vertebræ of the structure; and I also admit that, in a great many instances in the trade of iron ship building, as in every other trade, there is a want of scientific attention to the details of construction; but in all well designed iron ships, I think Mr. Taylerson will find that what he scientifically sets about doing, and doing in a very nice way, is, or should be, attained from the system adopted of breaking the joints of the plates. I think it is unfair to say that, because the ribs are vertical, at right angles with the keel, therefore the plating is of the weakest possible structure. On the contrary, as the plates in their length have their joints broken, as in the ordinary bonded brickwork, supposing the proper dimension of rivet and rivet hole to have been selected in proportion to the thickness of the plate, the rivet holes should not be the weakest part of the plate. If it were so, I need not say that the Britannia Tubular Bridge would be an exceedingly weak structure. But, as in the case of the Britannia Tubular Bridge and every other hollow girder, whether it be on that large scale or smaller, the strength of the structure depends upon that plating—for, take the plating away, and you have a bundle of square rings, parallelogram shape, which being framed together by longitudinal bars, and plated externally, form the girder; and it is upon the external plating that the strength of the tubular girder bridge depends. It should be the same in

Digitized by Google

every well constructed iron ship. I quite admit that from the want of attention, as I before observed, defects do creep into the construction of iron ships, especially where they are built by contract at very low prices, very often at prices that are unremunerative to the builders; and there lies the great secret of the defect of the most elegantly shaped ships.

Passing from that subject, I come back to the point of the principle proposed by Mr. Taylerson. He has brought before you an exceedingly interesting subject, though I think he will have more difficulty in carrying out his plan to the high state of perfection which has been attained by the present system of iron ship building than he at present sees. I hope I may be wrong—I wish him every success; but whenever you commence a structure where the lines are constantly varying, and such a structure as an iron ship, where you require well-defined lines, if there is any truth in Mr. Scott Russell's wave-line theory, we ought to be able to determine at every three inches, or every one inch, the exact curves taken at every part of the ship, and to be able to set them out by templates. Mr. Taylerson would have some difficulty in laying down his lines upon the floor, considering that these ingenious and beautiful angle ribs are constantly varying. It becomes an exceedingly difficult thing to lay out a ship with the varieties of curves such as you can obtain by the present system of iron ship building. That is only a matter of opinion; however, it is one which I think, nevertheless, deserves some attention by Mr. Taylerson. Upon the question of weight, to which I alluded in asking Mr. Taylerson the question I did as to the expense, if you place your ribs at the same distance apart it is pretty clear you would have a greater weight for the same dimensions; and I think 5 per cent. is a very small increase of cost for the increased strength which Mr. Taylerson gets by his improvement. I do not exactly understand the arrangement as to the watertight bulkheads. If it is to give greater resistance to the column of water, which unfortunately is not provided for in all vessels, that part of the vessel being in some vessels which I have seen quite disproportioned to the other parts,—and if Mr. Taylerson carries out the improvements he has represented as pertaining to his keel, and which I certainly believe do belong to that system of building, he will have effected a very great desideratum in the construction of iron ships.

Capt. FISHBOURNE.—Will you explain how you get over the difficulty alluded to by Mr. Smith as to the moulding?

MR. TAYLERSON.—Iron, when hot, readily takes any form. We had a little trouble at first in laying down this first ship, but as we went on we found very little more trouble than in the common mode. When we first began there was a little difficulty, but afterwards, when we got into play, we got the frames just as well moulded as the common ones. I think you spoke of ships not breaking up?

MR. SMITH.—No; unfortunately that is too true. I think it is more from the defect of the keel itself than from the structure.

Capt. FISHBOURNE.—Notwithstanding Mr. Smith's objections, I go entirely with Mr. Taylerson. I think the condition of the present mode of iron ship building is pretty much what that of the wooden ships was before the introduction of Sir Robert Seppings' trusses; and the only difference between iron ships as now constructed and wooden ships before that time is, that in the wooden ships the planks were put edge to edge, there being no means of attaching them to each other except the bolting through the timbers, while in the iron ship you overlap the plates of iron and rivet through them, which gives great strength in the direction of the ribs. But there is an important point which deserves to be remarked on, which makes it all the more necessary that iron ships should be stronger in the direction of the length, and that is, the want of elasticity in iron. Thus a heavy sea acting upon a ship's quarter lifts her; as a necessary consequence there is a bending action set up, to which the weakest part, generally that near the middle, yields, and the iron, not having elasticity, remains in a bent position; then another and another sea comes, and causes further bending, till it establishes a crack. That was the case with the Nemesis.

It is also frequently the case that parts of ships are borne down, or not supported by an amount of buoyancy equal to the weight in these parts, from which there is a constant stretch upon the centre part of the ship, and a tendency to break. In ships on the old plan, the strain falls between the timbers, therefore no strength in that direction is afforded by them, whereas in Mr. Taylerson's system the breaking force must cross a series of timbers, say 18 or 20, before the ship can break. That I think is a marked distinction, and an exceedingly valuable one. Another point with respect to iron ships is this, that although the sleepers upon which the engines are placed run a considerable distance along the ship, affording proportionate strength, and although there have been many plans to obviate the remaining weakness, by girders, making the sleepers in the form of girders, so making an inverted arch on which the engine is placed, still weakness exists beyond the parts reached by them. This Mr. Taylerson's method entirely obviates. Indeed Mr. Smith admits that it is a very ingenious and important principle if the weight is not materially added to. In a man of-war it is of course a very important thing to give excessive strength to the ship—and in plate-sided ships one of the greatest difficulties is to have a frame-work of sufficient strength to bear the iron plating. By Mr. Taylerson's plan a great deal of strength is added to the watertight bulkheads, because the strain is divided over a number of timbers, instead of being confined to one or two. When it is estimated that £80,000,000 worth of property is constantly afloat belonging to this country, and which is gradually finding its way into iron vessels, the importance of the subject becomes manifest. I have much pleasure, Mr. Taylerson, in conveying the sense of obligation under which this meeting feels to you, and I trust your invention will obtain that approbation from the public to which it is entitled.

Mr. Thornton's Report.

Having had much practical experience in the manufacture and testing of iron, and the strength of structures built of that material, I have every confidence in stating that the diagonal principle, as developed in the ship now in course of construction by Messrs. Robert Taylerson and Co., at Port Glasgow, exhibits vast superiority in strength over the vertical principle upon which iron ships are usually built.

Suppose a ship to rest upon a fulcrum in the centre of its keel, and equal weights to be placed at each extremity, with a tendency to tear the ship asunder vertically amidships, as shown in the accompanying plate,—then,

To tear asunder a ship built on the vertical principle, size and weight of metal being the same as Taylersou's, a strain would be required equal to 11,610 tons weight at each end,—whereas,

A ship on Taylerson's diagonal principle would bear a strain equal to a weight of 23,152½ tons without any injurious effect upon the vessel. (See plate.)

These calculations are based on the strength of iron structures as ascertained by experiments in the construction of the Menai Bridge and other works of great magnitude, and the arrangement and distribution of material in ships built upon the vertical and diagonal principles respectively; and they clearly demonstrate that no ship built on the vertical or longitudinal principle can bear anything like the same amount of pressure or strain as that which might be borne without injury by one constructed on Taylerson's patented diagonal principle.

ROBERT THORNTON, C. & P.E.

St. Leonard's Iron Works, Edinburgh,
15th November, 1858.

THE ROMAN VILLA AT APETHORPE.

AT a meeting of the Architectural and Archæological Societies of the Archdeaconry of Northampton and the Diocese of Lincoln, held on the 6th ult. at Stamford, the following paper was read by the Rev. Edward Trollope, on the Roman villa at Apethorpe:

Mr. Trollope said,—Very appropriately was the earth represented by the ancients as a fruitful mother possessing ample sustentative powers, but with at least as much truth was her title of "Bona Dea" characteristic of her preservative character, seeing with what care she broods over such works of man as may be committed to her charge, hiding them awhile when annihilation would certainly attend their revelation, and only revealing them when their value may be appreciated and their safety insured. Thus for some centuries the soil of Northamptonshire has veiled from view the remains of a Roman villa, when ignorant destruction would have followed its exhibition, but has now at length most discreetly thrown these open to view, and placed them at the disposal of the present noble owner of Apethorpe, with the utmost confidence that such an unexpected act of liberality will be duly appreciated. As straws show which way

Digitized by Google

the wind blows, so the merest trifles often lead to valuable results. Long had the genius of the spot about to be noticed sat in silence, declining to speak of the artistic pavements, the hypocaust, the pottery, and the coins left in his charge by his classical patrons, although those treasures were all the while lying only just beneath the surface. At length, however, he made a sign—gave a mere nod as it were, but it was sufficient. A drain was about to be made in Apethorpe-park, and in excavating the ground for that purpose something like an ancient drain tile was discovered, which immediately attracted the notice of one whose mind, accustomed to fathom the secrets of nature, could not allow such a circumstance connected with art to pass by without investigation. I allude to the Rev. M. J. Berkeley: his first step was to send me an impression of the scoring of this tile, accompanied by a request that I would assign a date to it. My reply was, "You have found a Roman flue, and if you dig in the vicinity you will be almost sure to discover a Roman building close by." Shortly after this I had the satisfaction of hearing that search had been made by Lord Westmoreland, who was then carrying on the diggings with the greatest zeal, and of receiving a note from Mr. Berkeley, in which he said, "If you had been on the spot you could not have delivered a more accurate judgment, for we have found a Roman house at Apethorpe."

The date of this building cannot be fixed with any degree of precision, but it must be looked for within the period bounded by A.D. 79, when Agricola, having subdued the whole of this island, began to encourage peaceful pursuits, and A.D. 410, when the Emperor Honorius gave up all title on the part of Rome to further dominion in Britain. We have therefore a period of upwards of 300 years from which to select the date when Roman workmen, aided by British slaves, were engaged in building the country residence now under our notice; but as it was probably long after Agricola's time before Roman families dared to live in detached rural residences, and from internal evidence of its own, this house can scarcely be assigned to a date earlier than the fourth century. But to what a wonderfully different scene do the 1500 intervening years lead us back in thought! Stamford and the various lines of railway connected with it are now ready to supply all the wants of the noble occupants of Apethorpe House, or to convey them to any other part of England, but a very different town and road were then the attractions leading the Roman proprietor of its site to establish himself on that spot. Six miles to the east of it there stood the great town of Durobrivæ on the Nene, well supplied with all necessaries from the surrounding fertile district, and with at least occasional importations from Rome—a little stale perhaps, but well enough for distant colonists of the remote Britain. The site of the town is still clearly indicated by an entrenched camp of an irregular oblong form, a little to the south of Castor and of the Nen, but its principal buildings appear to have been grouped round Castor church, and were noticed by Stukeley, and examined by Artis. More have been revealed in Normangate field, between these two points, others on Mill-hill, and many in Water Newton. From this town and its suburbs a rich array of pavements, altars, furnaces for smelting iron, potters' kilns, pottery, glass, spears, knives, hatchets, buckles, beads, pins of bone and jet, and a vast quantity of coins have been extracted. Hence the Roman occupants of the Apethorpe villa could readily travel to the south along the great Ermine-street, which actually intersected the camp of Durobrivæ, by Durolipons, or Godmanchester, Ad Fines, or Broughing, to London; and also to the north by Causennæ, or Ancaster, the great Lindum Colonia or Lincoln, Segelocum or Littleborough on the Trent, and Danum or Doncaster, to Eboracum or York, the second city of Britain under the Roman rule. Durobrivæ also possessed the convenience of water communication; for, dropping down the Nene to a spot on the outskirts of the present Peterborough, the southern mouth of the great Roman canal to Lincoln could be reached, now termed the Car-dike, whence by the Witham, the Fossdike, and the Ouse, goods could be taken to and from York and the north; whilst, on the other hand, by passing into the Wash, or Mentoris Astuarium, as it was then termed, such Roman traders as dared to carry on their traffic over our strong northern seas could fetch and carry goods from the south, and bring goods from London, Gaul, and the Imperial City. But another smaller road, or *via vicinalis*, still existing for the most part as a grass lane, was much nearer to Apethorpe than the Ermine-street; it ran within a mile and a half of the villa on its course from the Nen at Fotheringhay, a little to the east of Wood Newton, by New Sulehay, Whiteley's Coppice, on the eastern edge of Bedford Purlieus, across Wittering Heath, by Stamford racecourse, and joined the greater road in Burghley-park.

The Apethorpe Villa is by no means a solitary evidence of the former occupation of this portion of Northamptonshire by the Romans, either remains of their habitations, or evidences of their industrial pursuits, having been discovered in Sibson, Stibbington, Sutton, Wansford, the Bedford Purlieus, King's Cliffe, Tixover, Bulwick, Weldon, and Cotterstock. We may ask, then, what was the attraction that led the Romans to scatter themselves so thickly over this district in detached houses?—and the reply will be, "iron and wood!" The ironstone of Northamptonshire has of late attracted much attention, not as a novelty, but because the formation of railways has rendered it in some instances valuable in the metallurgic market. It was, however, still more valuable to the Romans, because of the forests that then so amply covered this portion of Northamptonshire—long in some measure represented by Rockingham Forest, and still indicated by the abundant remnants of the same preserved in many of the existing parks and woods of this district. They had not to convey their ironstone to a coal district, because they had an abundant supply of charcoal at hand, and most ample use did they make of it, as evinced by the many spots still covered with iron slag, cinders, and ashes, interspersed with coins and other unmistakeable Roman relics. Three such spots exist in the adjoining parish of King's Cliffe, viz., in the churchyard at Lordly-well and Redford,—and two others in Bulwick, one by the Willowbrook, on the confines of Blatherwycke parish, where there is a mound of slag, and the other in Blacklands, where the soil to a very considerable extent is still darkened by the charcoal, ashes, and slag of the Roman furnaces once existent there, amongst which not a few Roman coins have been from time to time discovered; but, still more wonderful, a furnace itself was disclosed at Wansford some years ago, and figured by the late Mr. Artis. The ironstone was first roasted in a kiln by the Romans, and then placed upon charcoal in a funnel-shaped pit, constructed of stone lined with clay, having holes at the bottom for the double purpose of letting in air and allowing the metal, when melted, to flow into a channel, whence it was distributed into pig moulds. Such a rude mode of smelting of course led to much waste, and will account for the great quantity of iron scoriæ or slag always found about the sites of these old works, and from which much metal might, I believe, in many instances be still extracted. I am not prepared to conjecture that the original Roman possessor of this villa at Apethorpe was an ironmaster, but I am inclined to think that the iron trade was the cause of his settling here, as a merchant or large farmer, if not as an ironmaster, the character of the villa not pointing to a higher personage.

Let us now examine the remains of the villa. It had a frontage of 200 feet facing the north-east, and the little streamlet termed the Willowbrook, a tributary of the Nene. From this front a set of baths, tailing back at one extremity, and more buildings reaching still further back at the other. It would be useless to conjecture the character of the several apartments whose foundations have just been revealed, excepting those clearly used as baths; but we may observe that the masonry of their walls is all built with inclined layers of stone, like those at Durobrivæ, and that they are chiefly dependent for their stability upon their thickness and the excellence of the mortar used: the irregular shapes of several of the rooms also should be observed—a very common, but to our idea a most uncomfortable arrangement, in several instances no sides of a room being parallel with their opposite walls. In the corner of one is a large stone, once serving as the bottom of a drain from above, and at the back is a small portion of a circular wall, apparently surrounding a dipping well that had been lined with hard, rudely formed slabs. From the plan of the villa, very carefully made by Mr. Browning, the position of the baths will be clearly seen, intersected by the modern drain which led to the discovery. The first small apartment probably was the charcoal and ashes receptacle: the second contained the furnace, whence by means of a channel the heat passed into the hypocaust beyond; this is narrow at first, having two "pilæ" only, and then widens into a square, originally having sixteen such supporters of the pavement above; next, two very large pilæ will be seen, four times the size of the others, and beyond these twenty more ordinary ones arranged in five rows. Adjoining this hypocaust on the right (looking towards the river) was a narrow room, and on the left one that had a tesselated pavement, both of which may have been used as "apodyteria,"

Digitized by Google

or dressing-rooms, and beyond the former was the cold plunging-bath, 8 feet long by 6 feet wide, lined with a coating of cement, and supplied with a drain for the exit of the water; round the bottom is a plain plinth in cement, and the whole may possibly have been lined with thin slabs of Aswalton or other marble, similar to some at Durobrivæ. The pilæ of the hypocaust are constructed of bricks 8 inches square and 1¼ inch thick, set in mortar nearly an inch thick, and strengthened with cement at their bases, excepting the two large central ones, which are four times the size of the others, taking four bricks to form one layer instead of one, and these I imagine were so placed to form a divisional wall, and perhaps also to support a "labrum" or hot-water bath above. Over the furnace was probably once the boiler for the supply of hot water, and over the hypocaust, first, the "caldarium," or hot vapour bath, with a "laconicum," or exceedingly hot recess, at one end, and the marble basin of the hot-water bath at the other; and then the "tipidarium," or cooler apartment, would be over the other portion of the hypocaust, so as to communicate conveniently with the cold-water bath beyond it. At one corner of this last a groove will be seen cut in the stones, which I can only conjecture has been connected with weighted "valvæ," or swing doors to prevent the cold air from passing into the tipidarium or other warmer apartments.

These baths were abundantly supplied with water, either from the little river close at hand, or from the springy rising ground behind the villa, but probably from the latter, as from the very low situation of the building its Roman owner was almost compelled to protect it by artificial drainage from the often too abundant waters descending into the valley, and by so doing he could also make them pay toll to his baths to the amount required, as they passed on to the river. But even if this villa had been placed far above the stream, and occupied the highest site in the vicinity, the knowledge of hydraulics and the engineering skill possessed by the Romans would soon have compelled the water to ascend to it. Most wonderful ignorance has until lately prevailed with regard to Roman information on such points, and Roman practice. Formerly it was generally considered doubtful whether the Romans possessed "fontes salientes," or jets d'eau, at all, although in reality the atrium, or open court, of almost every Roman citizen in southern Italy could boast of one or more; and no wonder, for most of the Roman towns having been supplied with water by means of aqueducts, whence it was conducted along their principal streets, any one who wished for the luxury of a jet d'eau within his premises had only to apply to the town "librator" for leave to join a private pipe on to the public one, and to pay for this accommodation in proportion to the diameter of his pipe, in order to possess himself of so agreeable an appendage to his mansion. But the knowledge and skill of the Romans went further: they not only were fully aware that water would always find its own level,—Pliny saying plainly enough, when speaking of water, "subit altitudinem exortus sui," and a Roman leaden pipe having been discovered at Arles, that extended under the Rhone, for the purpose of conveying pure water from one bank to the other;—but they could force water up from a lower to a higher level by mechanical power. The channel, or pipe, required for this purpose may be seen in Nettleham parish, Lincolnshire, which once conveyed water from a spring there to Lincoln, a distance of a mile and a half; it is formed of circular earthenware tiles, 6 inches in diameter and 22 inches long, set in a thick casing of cement, so as to exclude the air entirely, and to strengthen and protect the piping. There is a considerable rise from the spring when this watercourse first leaves it, consequently the water must have been propelled thence by art. We should, of course, effect this by a force-pump, by an hydraulic-ram, or by steam power; the Romans did so by the first-named means, using an engine called "ctesibica machina," because it was invented by Ctesibius, the son of a barber of Alexandria, who lived B.C. 135. This was greatly improved by Heron, the pupil of Ctesibius, who has left a description of it. Vitruvius and Pliny also minutely describe this engine, whence we gather that it was just like a modern fire-engine pump, and could force water up a pipe of almost any length required; but happily one of these still exists, found at Castrum Novum, near Civita Vecchia, during the last century, which had been used for the purpose of pumping up water to the public baths of that town from below, during the palmy days of Rome.

Over the pilæ of the hypocaust flanged tiles were laid, and upon these three coatings or layers of pounded bricks, sand, and lime, each finer than the other, and termed respectively ruderatio, rudus, and nucleus. Upon the surface of the last the artist then arranged his tesseræ or small cubes of stone, terra-cotta, marble or glass, so as to form those graceful and sometimes most artistic designs which still attest the skill of the Roman artificers in this department. Unfortunately, the pavement over the hypocaust, usually the best in a Roman villa, is altogether wanting, but another still remains in a tolerably perfect state of preservation. This is for the most part composed of plain and rather coarse tesseræ, but in the centre is a square compartment of that species of mosaic work termed "opus vermiculatum." At the four corners are vases, from which issue branches suggestive of the honeysuckle tube and its stamens, or some similar floral produce; within is a circle having a double border, the one ornamented with small semicircles, the other with figures something like galley prows; this incloses a central square compartment, which, although not rich with the form of Orpheus, and the beasts enchanted by his lyre, nor with Ceres, nor Actæon, nor an ornamental vase, as were other pavements, yet contains one which at least has the merit of novelty. At first, taking it in conjunction with twenty-four little crosses once appearing around it, I thought that figure might possibly point to the faith of the original owner of this house. I should not have been deterred from entertaining such an opinion because the Christian emblem of the cross was mixed up with the Pagan altars or other evidences of heathenism, the inmates of a British house of the Constantine period probably in many cases holding very antagonistic religious opinions, so that the master might have adopted the Christian faith, whilst the servants, or some of them, retained the creed of their youth; or even husband and wife, or parents and children, may have totally disagreed on this head. Hence altars dedicated to Mars, Mercury, Faunus, or to the imaginary tutelary deities of particular localities, may be found in certain portions of a Roman house, indicative of the cloud that still enveloped some of its inmates, whilst elsewhere the Christian insignia may clearly indicate that a light had pierced the darkness there, and that truth had prevailed against fiction, as in the instance of the Roman pavement found near Dorchester, and figured by Lysons, whereon the "labarum" of Constantine, composed of the two first letters of our Lord's title, appears in conjunction with a head of Neptune. But as the cross alone, even when distinctly figured beyond all doubt, is so simple a form, we cannot be surprised to find that it has often been portrayed by Roman polytheist artists simply as an ornament. In the centre of the Roman pavement found at Cotterstock something like a mediæval cross was displayed, which I mention as an example in this vicinity; but there are many others, such as the one found under the Bank of England, and figured by Mr. Roach Smith, in his 'Illustrations of Roman London,' displaying in its centre an ornamental figure precisely resembling a foliated mediæval cross. I cannot therefore suggest, without further evidence, that we may here grasp even at the shadow of the cross. The whole pattern of this pavement is formed with terra-cotta tesseræ, here and there mingled, or slightly touched up with others of a dark grey upon a white ground. Near it was a floor faced with carefully smoothed plaster, painted red, belonging to an adjoining room. These floors are not common, but one such was found at Cirencester, and I am informed by Mr Roach Smith that he has observed one or two others in London.

The appearance of this villa, when perfect, was not the least like a Pompeian house, or one in the Roman metropolis; small shady courts and large open cisterns would never have suited a climate like that of England, and no attempt was made to introduce them here. English villas, like the one before us, always appear to have consisted of detached features of very different sizes, and probably of different heights, like the Italian country houses occasionally portrayed on the walls of Pompeii, which could be altered or added to with the greatest facility by their respective owners; and a wall continued along the river front of this Apethorpe villa, terminating with a large stone placed there apparently to mark its end temporarily, appears to point to an intention on the part of its former owner to have added to his house, which he never fulfilled. The roof was for the most part covered with flat flanged tiles or "tegula," of which heaps of fragments were discovered, some still having the iron nails in them once serving to fasten them on with, and also many of the semicircular tiles, or "umbrices," which were placed over the flanged ends of the flat ones. It is interesting, however, to perceive that the Romans were fully aware of the merits of Collyweston slate, as a portion of this villa was certainly covered with

Digitized by Google

that material, some slates from that district and other thin slabs of the Whittering pendal stone cut with flat edges, and some in a diagonal form, having been found here, pierced with nail holes.

I regret to say that the Apethorpe diggings at its recently opened Roman mine have been unusually unremunerative. Some scored flue tiles have been found (1 ft. 3 in. long, 7½ inches wide, and 3½ inches thick), and a very few small coins, among which is a third brass of Constantine the Great, bearing his effigy and the inscription "Imp. Constantinus Aug." Reverse, "Soli invicto comiti," with Phœbus holding a sceptre in the right hand and a globe in the left. Two small rude dilapidated altars were also disclosed, one quite plain, that had been inserted in a wall, and the other having a pan on one side and a "tripus" apparently on the other. The fragments of pottery even were not abundant, but some so-called Samian, Durobrivan, grey and cream colour specimens were turned up: amongst the last were two fragments of mortars, studded, when soft, with pounded slag or iron scoriæ, of different degrees of coarseness, to aid in the abrasion of cereal produce. A solitary spindle-wheel, a leaden article, perhaps a weight, and an abundance of oyster-shells and bones, conclude the short catalogue of objects offered to our notice by the excavations lately made in this vicinity, through the praiseworthy exertions of the Earl of Westmoreland. We should, however, be deeply ungrateful to Mother Earth if we murmured at the quality or quantity of her Apethorpe revelations, adding, as they do, one more link to the chain of our knowledge respecting the character and proportions of a Roman colonist's habitation in Britain; and if any are inclined to feel disappointed with what they have seen to-day, let those remember the extreme antiquity of the objects they have been permitted to gaze upon, that after a burial of 1500 years the shroud has been removed from remains that had previously suffered a fiery death, and have since been confined to an extremely wet tomb in a climate not well adapted to preserve such objects of art. But of this I am confident, that as lovers of architecture, ancient and modern, and as archæologians, the various members of the associated societies of Lincolnshire and Northamptonshire, must feel greatly obliged to the Earl of Westmoreland for the intelligent zeal he has exhibited in prosecuting his archæological diggings.

THE PUBLIC WORKS OF THE UNITED STATES.

THE following—a reply to an article which appeared in the *New York Times*, and which was given in our August number, page 268—we quote from the *Engineer* of the 2nd ult.

"We have no desire to detract from the merit justly due to American engineers. Many of their works show great boldness of conception, as well as skill in their execution. We should not wish therefore to hold the profession in America to account for the mass of absurdity and error contained in the article of the *New York Times*.

Rome had nine instead of seven aqueducts, and the Aqua Julia was 15,126 Roman paces only in length. The Croton Aqueduct is 40 miles in length. The Aqua Claudia of Rome was nearly 50 miles in length. According to Frontinus the nine aqueducts of Rome supplied upwards of 360,000,000 gallons every twenty-four hours. The aqueduct at Carthage was 50 miles in length; and near Udina a thousand arches of beautiful masonry, upwards of 100 feet in height, remain of another aqueduct built by the Carthagenians. The aqueduct near Lisbon, crossing the Alcantara, consists of thirty-five arches of a total length of 2400 feet, and the total height is 263 feet. This vast structure withstood the shock of the great earthquake, and still supplies the water used in Lisbon. The Ponte Maddalone, erected in 1753, to convey the waters of the aqueduct of Caserta to the royal palace near Naples, is 1700 feet long, and has three series of arches rising to a total height of 179 ft. 7 in. The famous Pont du Gard, or Aqueduct of Nismes, dating from before the Christian era, is 882 feet long, and the line of the parapet is 161 feet above the water of the Gardon. It is constructed entirely of cut masonry; and all the beds are so closely jointed, and without mortar or cement, that Mr. George Rennie found it in many cases impossible to insert the blade of a penknife in the joints.

But the aqueduct of Marseilles, commenced in 1839 and completed in 1847, is perhaps the greatest of its kind in the world. The length of the main channel is 51 miles, and of its branches and feeders 43 miles, making 94 miles in all. On the main line are thirty-six tunnels, of a length of 9·65 miles; and including the branches there are eighty-four tunnels of a total length of 13½ miles. The tunnel of Les Taillades is 12,024 feet long, that of Assassin 11,394 feet, and that of Notre Dame is 9867 feet long. But the greatest work of the whole is the Roquefavour Bridge, over the Arc, the length of the structure being 1289 feet, and its total height from the bottom of the foundations of the piers to the top of the parapet of the aqueduct 305 feet, of which 271 ft. 2 in. are above low water in the Arc! This aqueduct delivers 1,250,000 tons of water every twenty-four hours.

The Illinois Central Railway is 708 miles long, the main line being 454 miles, and the Chicago branch 254 miles long. The Grand Trunk Railway of Canada is now worked to the extent of 880 miles, of which 731 were made by the Grand Trunk Company. The longest existing railway now owned by one company is the Eastern of France, of 1011 miles in length. The Grand Russian Railway will be, when finished, 2585 miles in length. The Illinois Central Railway is a single line, laid with light rails; hundreds of miles are completely destitute of ballast, and the average speed of the passenger trains was, at a recent period, 17·9 miles only per hour. In point of workmanship we can state, upon reliable American authority, that the Illinois Central is not 'equal to any European road.'

Captain Meigs' stone arch, on the line of the Washington Aqueduct is, according to his own report, 224 feet span, or 24 feet wider than the granite arch of Grosvenor Bridge at Chester, the next widest stone span in existence, unless we are to believe the wonderful accounts of Kircher, the traveller, who asserts that stone arches of 600 feet span are standing in China. In 1390, however, a granite arch of 251 feet span was standing over the Adda at Trezzo, in the Milanese. It was erected by order of Barnabó Visconti, Duke of Milan; and had it not been purposely destroyed by Carmagnola, might, very likely, have been standing yet.

The tunnel at the summit of the Pennsylvania Railroad is 3612 feet long, and cost £92,000, from which we infer that it was *not* as difficult of construction as the Thames Tunnel. For several months 175 American gallons of water were said to have been pumped per minute from the shafts of the Pennsylvania Tunnel, equal to less than 1000 tons of water daily. The mode of driving this tunnel was precisely the same as that adopted in all railway tunnels.

The works at Harper's Ferry are of much less extent than the Starucca Viaduct, the largest work of its kind in the United States; and it is only necessary to state that the latter viaduct, according to the published description, is of uncut stone, about 1100 feet long, 105 feet high, and having eighteen semicircular arches of 50 feet each. The work is wholly destitute of ornament, and has not even parapets on the sides of the railway, which is carried as a single line only at the top. It is certainly unnecessary to stop to compare such a work with those of either Brunel or Morin.

We believe there are but three or four large railway viaducts of masonry in the United States—the Starucca, just described; the Canton, on the Boston and Providence Railway; and the Carrollton, on the Baltimore and Ohio Railway, being the chief works of this kind. Without mentioning the Britannia, Conway, Saltash, or Chepstow bridges, or the High-level Bridge at Newcastle, we may take a hasty view of several railway viaducts executed in stone and brick in various parts of Great Britain and on the continent.

Name of viaduct.	Line of railway.	Material.	Total length.	Total height.	Number of arches.	Span of arches.	Cost.
			Ft.	Ft.		Ft.	£
Llangollen...	Shrews. & Chester	stone	1530	150	19	90	110,000
Ceiriog	do.	,,	850	120	11	45 to 120	
Congleton ...	London & N. W.	,,	3078	98	...	...	113,000
Stockport ...	do.	bk. & st	1792	106	22	63	72,700
Dane	do.	brick	1717	88	23	63	54,000
Dutton	do.	stone	1284	84	20	60	53,103
Ouse	Lon. & Brighton	brick	1437	96	37	30	
Lockwood ...	Man., S. & Lin.	,,	1500	136	34	30 to 70	33,000
Victoria.....	North Eastern	stone	812	...	10	20 to 160	38,000
Ribble		,,	750	50	5	120	40,000
Barentin ...	Paris & Havre	...	2295	108	27	60	
Indre.....	Tours & Bordeaux	...	2624	65	59	30	80,000
Durance ...	Mars. & Avignon	...	1968	...	...	...	120,000
Arles	do.	...	2526	...	31	69	80,000
Rhone	Paris & Lyons	...	...	...	...	...	240,000
Goltzsch.....	Saxon Railways	brick	1900	264	...	...	271,500
Elster	do.	,,	853	229	...	...	114,000
Kalte Rinne	Soemmering	,,	600	150			
Starucca ...	New York & Erie	stone	1100	105	18	50	22,000

To this list might be added the Wharncliffe, Sankey, Ogden, Foord, Etherton, Anker, Bollin, Avon, and numerous other viaducts in England, all larger than any American works of the same kind, excepting the Starucca Viaduct. Iron viaducts, for which so many of our railways are celebrated, are left out of the above list, as are also the great Victoria Bridge, the largest in the world, nearly completed by English engineers at Montreal; and the great bridges at Cologne, Kehl, &c., also in course of construction.

For boldness of design, however, the Ballochmyle Viaduct on the

Digitized by Google

Glasgow and South-Western Railway, constructed some twelve years ago by Mr. John Miller, C.E., surpasses any other railway stone viaduct in the world. It is 635 feet in length, having three arches, of 50 feet span each, on each side of the great arch, which has the widest span of any masonry arch yet constructed for railway purposes. This arch is a semi-circle of 180 feet clear span, being 28 feet wider than the central arch of London Bridge, and the total height from the surface of the river to the top of the parapet is 162 feet.

The viaduct of Ariccia, recently built by the Roman government to carry the public road between Albano and Ariccia, is of stone throughout, and is 1020 feet long and 201 feet high. It has three tiers of superposed arches, the upper series, eighteen in number, of 30 feet span, being 71 feet high. The work contains 4,175,882 cubic feet of masonry, and cost a little less than £30,000.

We believe that the Americans can justly claim to have the widest single suspension span extant, but in all other respects their suspension bridges are immeasurably surpassed by the great work erected by Mr. Charles Vignoles, under the order of the Russian government, across the Dnieper at Kieff. This bridge, commenced in September 1848, and opened in October 1853, has six spans, four of 440 feet and two of 225 feet from centre to centre of towers. Its entire length is 2562 feet, each of the four great chains being 2280 feet long, and weighing together 1578 tons. The whole weight of iron in the bridge, all furnished by Fox, Henderson, and Co., of Birmingham, and by Musgrove and Sons, of Bolton-le-Moors, weighs 3500 tons, and there are 1,500,000 cubic feet of masonry, brick, and concrete. The whole cost of this bridge was £432,000.

We believe also that the new graving dock at Southampton is larger than that at Brooklyn. The former is 425 feet long on the floor, the gates being 80 feet wide, and is 25 feet deep over the sill. It can be emptied in three hours.

As for the Lockport locks, of which full particulars are on record in this country, they comprise a lift of five locks, rising 12 ft. 6 in. each, excavated in solid rock. Few locks, perhaps, other than these and those of the Trolhoetta in Sweden, have been constructed in the same manner; but for magnitude the Lockport locks are far exceeded by those of the Welland Canal in Canada, which is, by the way, less than 50 miles distant from one end of the Erie Canal. The Welland Canal, only 36 miles long, has twenty-seven locks rising 346 feet, each lock being 150 feet long and 26½ feet wide, those of the Erie Canal having been originally made 90 feet long and 15 feet wide. The locks at Loch Eil, however, on the Caledonian Canal, are to our mind far more grand than anything of their kind ever constructed in America or elsewhere. They comprise a flight of eight locks, each 180 feet long and 40 feet wide, overcoming a total ascent of 64 feet. They form a mass of magnificent masonry of 1500 feet in length. They were constructed some fifty years ago by Telford. The five connected locks at Fort Augustus, on the same line, are each of the same dimensions and construction, their whole length being about 1000 feet, and their total lift 40 feet. The locks at Fonceranne, near Beziers, on the Canal du Midi, or Languedoc Canal, in the South of France, form a mass of masonry 960 feet long, in which the boats rise by eight lifts through 68 feet.

As for the lighthouse, we are glad indeed to hear of the immense strength of the new structure on Minot's Ledge, the former lighthouse having been destroyed in a storm a few years ago, the keepers having been also lost. Our American friends will recollect that the Eddystone Lighthouse was completed in October 1759, and that it has withstood the blasts and seas of a century with no injury whatever.

About the bridge at Wheeling, it is a pity to say that it was once wrecked in a gale which swept down the Ohio; so that, with whatever strength it may have been rebuilt, we suppose it is hardly too strong even yet.

As for grand carpentry, the Americans are only behind the Swiss of old John Grubenmann's time, whose timber bridge, near the Abbey of Wittengen, constructed similarly to the Schaffhausen Bridge, had a clear span of 390 feet, the widest ever executed in timber, and wider by 115 feet than any timber span now standing in America. But for the French, who burned down Grubenmann's great work in 1799, it would doubtless have been standing yet. The Americans have a bad habit of erecting timber structures which 'have not their equals in the world' for unsound materials and reckless workmanship; and to the frequent fatal failures of these affairs the American journals too painfully testify. We are sincerely pained to hear an American at any time boast of the timber bridges on the railways of that country, unless it be, perhaps, of McCallum's truss, which appears to be the best of the whole.

As for American railway speeds, the statement that they average as high as those upon English lines is a silly and empty boast. On no other railway in the world is a train run with the speed of the Great Western express between Didcot and London, 53½ miles regularly in one hour ten minutes, or 45¾ miles per hour. The quickest trains running on the Hudson River and New York Central Railroads, on which the fastest trains in the United States are run, average much below 40 miles an hour.

American engineers have generally laboured under disadvantages in respect of means where our own engineers have been practically unlimited in expenditure. Yet while this circumstance goes to explain the undeniable inferiority of the majority of American as compared with European works of construction, there is, nevertheless, a want in America of proper caution, of concientious care, and an almost total absence of anything like governmental interference. The consequence is, that the American railways are disgraced by wholesale disasters; they are very expensively worked; and lines which were opened under apparently the most auspicious circumstances are continually drifting into bankruptcy. We assert no more than every well-informed American will freely admit; and we make these observations in no other spirit than that of a just regard for the noble profession in which English and American engineers claim equal fellowship."

REVIEWS.

The Stones of Etruria, and Marbles of Antient Rome. By GEORGE L. TAYLOR, Architect.—London: Longman and Co.

The name of Taylor has long been honourably known in the architectural world, in connection with the late Mr. Edward Cresy, as an explorer of the remains of ancient Rome; and this recalls to mind the researches of other fellow-labourers in the same field,—for instance, the Dilettanti Society, whose works were published in a collected form, and not, as in Taylor and Cresy's case, by the enterprise of the individuals themselves. After a lapse of nearly forty years Mr. Taylor has revisited the scenes of his former labours, and now mentions, incidentally yet naturally, that in the intervening period the monuments which he had before seen and drawn and published have deteriorated much; while, on the other hand, much has been achieved in the way of patient excavation and bringing to light other objects, not only interesting in themselves, but also assisting to identify or correct former conclusions as to the sites and remains of buildings.

The essay before us, which owes its origin to a paper read at the commencement of the year, on the subject in question, before the Institute of British Architects, forms in its present shape, elucidated as it is by several plans and views, a worthy sequel to the earlier volume—'Antiquities of Rome'—of which it appears that a new edition, containing the architectural details of the subjects referred to in this publication, with the addition of the antiquities discovered since 1820, is in preparation, and will shortly be published.

Although, as our author truly observes, "the history of Rome and her monuments is unquestionably a noble theme," the only view of the subject embraced in the present volume has reference to the construction and probable periods of her ancient buildings, and the examination is greatly assisted by the diagrams and views to which we have already alluded, and without which anything like a fair attempt at analysis would be futile. It may however be stated, that a very careful engraving illustrates what is probably the most interesting part of ancient Rome, viz., from the Tabularium on the Capitol, over the whole area where once was the Roman Forum; the view extending to the Colosseum in the distance, to the arch of Titus, and to the Palatine Hill.

The eastern façade of the Tabularium, with its magnificent basement wall, was formerly (and is still nearly) 300 ft. in length, and 26 courses or 50 feet in height; each course being precisely 1 ft. 11 in. in height (2 ancient Roman feet, or 1 modern Florentine braccio). This wall is 11 ft. 8 in. in thickness, with piers equal in width to the openings; and it was found on careful examination that every stone in this vast building was a double cube of 1 ft. 11 in., that is 3 ft. 10 in. long, 1 ft. 11 in. high, and 1 ft. 11 in. wide,—all precisely of one size, laid in courses alternately "header and stretcher," and put together without any mortar or cement, with the finest joints, and with the perpendiculars truly kept in them. Above this basement was an arcade with fifteen openings, the piers having half columns in front, of the Doric order, with Greek Doric capitals and architrave. Several of these arched openings are clearly traceable, and in one the ancient masonry is exposed, but it was not considered safe to clear out more, with the high modern wall bearing upon them. Behind the front wall is a corridor, 15 feet wide, the whole length, arched. Below the Arch of Titus are the three beautiful columns of what used to be called the Temple of Jupiter Stator, but now supposed to be that of the Dioscuri, Castor and Pollux. Twenty names have been given to this temple, but Mr. Taylor considers the Dioscuri entitled to the claim.

"Between the Temple of the Dioscuri (which is restored on the plan to its whole extent) and the Temple of Saturn, nearly the whole area is

Digitized by Google

filled up by the pavement of an extensive building, lately discovered, which is supposed to be that of the Basilica Julia, built by Augustus and dedicated to his daughter.

By reference to the plan it will be seen, that from the carriage pavement of the Sacred Way there are for a considerable length, first, two steps and a landing of 4 ft. 4 in., then three other steps, then a landing of 3 feet, then a range of 6 inch marble pavement of blocks, 6 ft. 7 in. by 3 ft. 10 in., three in the width, then two other steps. Then another range of three 6 in. blocks, 6 feet by 3 ft. 10 in. each; these six ranges of large blocks remain in place, seventy-nine in number and six in width, in the whole length from east to west, filling up nearly the whole extent, viz., 300 feet. Then comes a range of 2 ft. 10 in. wide, which appears to mark the line of the wall, or piers of the building, to the north; of which piers there appear to have been sixteen, 20 feet from centre to centre. Then comes a thinner pavement, 1½ inch thick, probably over the covered part of the building. It is too much destroyed to make out the pattern.

In the will or record left by Augustus (called the Monumentum Ancyranum, wherein he boasts of having found Rome brick, and left it marble), this basilica is mentioned as adjoining the Forum, and extending from the Temple of the Dioscuri to that of Saturn. He states that he is constructing it, and leaves directions to his heirs to finish it, in case of his death before its completion. This would appear decisive, both of the certainty of its being the Basilica Julia, and also of the nomenclature of the Temple of the Dioscuri (formerly called Stator), and of Saturn (formerly called Concord). How *the* three columns could ever have been supposed to be the remains of the Temple of Jupiter Stator, built and dedicated by Romulus, is unaccountable. At the west end are five brick piers, with stone springers, and the commencement of arches. This building was repaired by Domitian; and these would appear to be his work, from the nature of the brick (or tile) work. All this is shown on the large plan, every stone being marked with its dimensions.

The modern road hides much of the recent excavations. I have therefore adopted a slide over the lower part of the view, by raising which are exposed the temples of the twelve Dii Consentes, and the columns in front of them, of light coloured marble. They are placed angularly, partly under and wholly hidden by the modern road. These columns are all about 18 feet high, and 1 ft. 10 in. diameter; the capitals formed of arms and shields, the shafts fluted, with astragals between the flutes, rounded at the top and bottom, and finished with a tongue between each, as in the interior columns of the Pantheon.

In front of these temples was discovered a marble pavement, or area, *under* which were the offices of the notaries or barristers—called the Schola Xantha, from the curators, Bebrix Drusianus and A. Fabius Xanthus, who adorned them with marble, and erected silver statues to the gods. The marble sills of these cells or offices remain, and there was an alley to the north, the pavement of which remains; and there was another range of offices on the north side of it. Here sat the lawyers to explain the laws to inquirers; at the end of the alley was an archway in the Tabularium wall leading to a staircase, by which they ascended to the upper part of the building, where the tables were deposited for reference. In the fire of Vitellius 30,000 of these tables of bronze were destroyed. The nature of them is known from some found and preserved at Gubbio. This archway was filled up with masonry, and the northern range of the Schola Xantha removed by Vespasian; who being miraculously preserved from a thunderbolt, which killed his armour-bearer, resolved to dedicate a temple to Jupiter Tonans, and to obtain a site on this most sacred Clivus, built up the archway, and removed the northern range of offices. This archway is now exposed to view, though still walled up; and after having much difficulty in obtaining permission from the senator, Prince Orsini, to plant a ladder, I followed the steps of this ancient staircase from an upper corridor (the steps up to which were also found, and are shown on the plan) down to the inside of this archway. In an angle of this staircase, when first discovered, were found office pens, or stili of the day, which are preserved in the Museo. This temple was in front hexastyle, the columns 47 feet high and 4 ft. 10 in. diameter. The nature of the returns is only supposed. The steps of approach must have been difficult of arrangement, from the small space between it and the sacred Clivus. That this is the temple so dedicated to Jupiter Tonans there appears no doubt, however uncertain the identity of some of the others may be.

To the north of this temple are the substruction and pavement of the Temple of Concord, also lately exposed. This temple, erected originally by Camillus, was restored by Tiberius. It appears to have been 150 feet in extent from south to north, and the cell 60 feet wide from east to west. In this great hall the senate was wont to hold its permanent sittings and councils on urgent affairs. It seems to have had a portico advancing in the centre, before the cell; and here Cicero addressed his celebrated orations to the assembled fathers, when he saved the state from the dangers threatened by the Cataline conspiracy. The foundation for the steps in front remains, reaching to within 35 feet of the arch of Septimius Severus, and the door-step of the temple is still in its place, being composed of two pieces of "Pavonazzetto" marble, each 25 feet in length, 4 feet wide, and 2 feet thick.

In the centre appear the pivots for the doors, with a sinking in the marble for a caduceus. The cell of this temple is peculiarly appropriate for public meetings, and the form of its façade is corroborated by medals. The whole area was paved with thin marble, the bedding of which and some of the paving still appear, also some of the masonry of the high altar, and the marble lining of some of the walls, to the height of 6 or 8 feet. (The same appearances are left in Jupiter Tonans.)

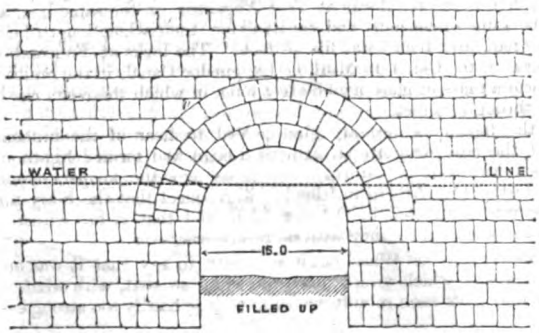
The substructions warrant the tracing of the front portico as hexastyle and systyle, as shown on the plan, and the columns must have been nearly or above 6 feet in diameter, and 60 feet high. It does not appear that, at the time of the excavation, any of the columns or capitals were found, but enough of the entablature was collected to enable Canina to set up, partly original, partly restored, a length of the whole entablature, which is represented on these drawings to the full size. The height of the architrave is 3 ft. 8½ in., the frieze the same, and the cornice 6 ft. 4½ in., total 13 ft. 9½ in. He has also set up a length of the entablature of Jupiter Tonans in the same corridor. This cornice is very finely designed and executed, and its analogy with that of the so-called "Jupiter Stator" is very striking. Concord has the advantage in size over Stator, but both bear the style of the Augustan period. As I before observed it was restored by Tiberius Cæsar.

* * * * *

Commencing historically, we will take the *known* works during the period of the seven kings, *i.e.*, from the foundation of Rome by Romulus, 753 years B.C., to Tarquinius Superbus, who was expelled in the 245th year of Rome.

The length of the reigns of these seven kings is worthy of observation. 1. Romulus, 753 B.C., reigned 38 years. 2. Numa Pompilius, reigned 43 years; he came from Cures, the capital of the Sabines. 3. Tullus Hostilius, reigned 32 years; in his time the war with the Albans and the conflict of the Horatii and Curiatii occurred. 4. Ancus Martius, reigned 24 years; he enclosed the Aventine and Janiculum hills, founded Ostia, built the Mamertine Prison, and the Sublician Bridge. 5. Tarquinius Priscus, reigned 39 years; he quitted the city of the Tarquins to come to Rome, built the Cloaca Maxima and the Pulcrum Littus. 6. Servius Tullius, reigned 44 years; he enclosed the Seven Hills with walls, a great part of which remain to this day, much having lately been discovered. 7. Tarquinius Superbus, reigned 24 years. His son's brutal rape of Lucretia eventually caused his expulsion from Rome; he fled to Tarquinii and claimed his Etruscan consanguinity. Porsenna, king of Clusium, marched to Rome with a large army in order to restore him, encamped on the Janiculum, and would have crossed the Tiber but for the heroic defence at the bridge by Horatius Cocles, who stayed the enemy while the bridge was destroyed behind him.

Of these works there still remain: of Ancus Martius—the Mamertine Prison, upper and lower; of Tarquinius Priscus—the Cloaca Maxima, and the Pulcrum Littus, or beautiful shore (the name of Pulcrum Littus was, I have no doubt, given to it from its beautiful masonry, which, on



careful examination, I have found to be of the regular Isodomon header and stretcher, and of the precise guage of 1 ft. 11 in. in height); of Servius Tullius—the walls surrounding the city and enclosing the seven hills. All these are of the time of the kings, and their dates are known; the stones speak for themselves; they are of tufo and all of the same dimensions, viz., the double cube of 2 ancient Roman feet—3 ft. 10 in. by 1 ft. 11 in. by 1 ft. 11 in. English,—the joints worked with the greatest precision, and without cement.

Two other most interesting examples of early construction in Rome, of known dates are—1. The Mamertine Prison at the foot of the Capitol. The *upper part* was built by Ancus Martius, and consisted of a vaulted room of an irregular quadrilateral form, built and arched with large tufo stones with fine joints. The *lower part* was subsequently excavated by Servius Tullius in the solid tufo, the sides walled in like manner, where the tufo could not be made to answer, with a very flat arch of masonry, of fine construction, serving as the floor of one and the ceiling of the other. In this lower prison it is said that St. Peter was confined, and a spring still remains, said to have miraculously sprung up for him to baptize his gaolers. And, 2. The walls of the city built by Servius Tullius, and which appear in various parts of their extent of 8 miles, particularly to a considerable length, lately opened up in the *Vigne del Collegio Romano* opposite the Church *Sta. Prisca*. The masonry of these walls is similar to that of the Tabularium—Isodomum, or with courses equal in height—1 ft. 11 in. or 2 ancient Roman feet, built "header and stretcher,"

Digitized by Google

but the stretchers longer than the double cube; in the course of these walls are arches of fine masonry, but the wall filled in under them.

During the republic the Romans were engaged in twenty-one serious wars, and we can trace but little the dates of their works of construction; however the Tabularium is a fine exception, the date of which we know by an inscription still visible, stating that it was constructed by Q. Lutatius Catulus, in the year of Rome 651, or 102 B.C. It is still "to the fore" nearly 300 feet in length, and 50 feet in height; the stone is Peperino or tufo; the courses Isodomum or equal, header and stretcher; every stone a double cube of 2 ancient Roman feet.

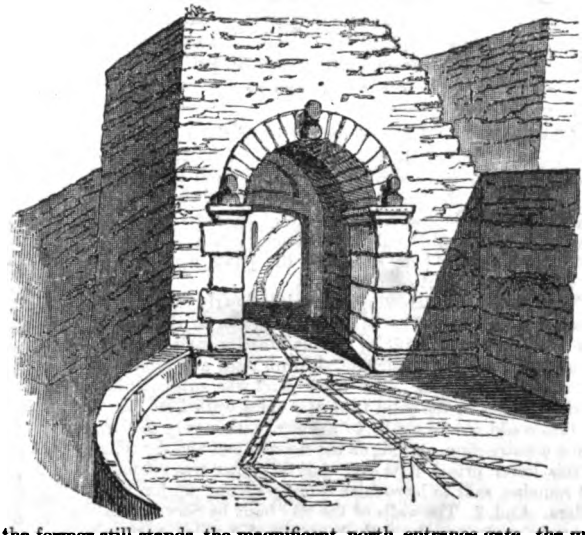
Of the works of which we know not the date, but which declare themselves to be as early, the finest specimen is the peribolus wall of the Temple of Mars Ultor. The temple itself was, it is believed, built by Augustus, but I imagine the surrounding wall is far anterior. About 500 feet in length of it remain, and to a height of 100 feet. It is Isodomum, or of equal courses; each course precisely 1 ft. 11 in., or 2 ancient Roman feet in height; laid in alternate courses, header and stretcher, but the stretcher courses are 3 cubes, or 5 ft. 9 in. in length. The cornice also is bold, and the skew arch (arco dei Pantani) is a magnificent piece of masonry.

There is also some masonry of tufo lately discovered at the foot of the Palatine Hill on the west side. The stones are double cubes of 2 Roman feet, jointed like those of the Tabularium, and bonded into the solid tufo of the hill, which is of the same material. These must be very ancient. I should observe that all the seven hills of Rome are composed of a mass of volcanic tufo, and that most of them have alleys cut through them in various directions.

Following up my hypothesis of judging of the dates of Roman buildings by their masonry, I must quote for the size of their stones, though not for such regularity: the tomb of Scipio, 456 A.U.C.; the tomb of Cecilia Metella, (Capo di Bove,) B.C. 67; one of the finest specimens of early construction, the circular surface being composed of the finest Travertine; the Island of Esculapius in the Tiber, constructed in the form of a vessel; the Theatre of Marcellus; the Colosseum; and the Temple of Fortuna Virilis. The Travertine stones of the cell of this temple are exactly to the guage of the 2 Roman feet, or 1 ft. 11 in. English,—a strong argument in favour of its reputed erection in the time of Servius Tullius, and its restoration in the time of the republic. The *early* date of all the above is thus clearly established."

In attempting to trace out the sources whence the Romans derived their magnificent construction, the author introduces us to *Etruria*, of which he made the tour in search of "old stones." Unfortunately the language of that age and country is yet to us almost a sealed book; but a member of the Collegio Romano, we are told, has propounded the idea that it is derived from the Hebrew, and, like the characters in that language, the words are to be read from right to left. The investigations made at various localities are then noted, and the results of each. Among the places thus chronicled are Sutri, with its walling, and Etruscan amphitheatre, walls more or less similar in construction at Nepi, Faleri, Fiesole, Cortona, Siena, Volterra, and Clusium. At Cœre they form the divisions of the land in lieu of hedges.

"At Perugia much of the Etruscan walling of the ancient city remains, with more extensive walls of *Braccio Forte Braccio*, of the 15th century.



In the former still stands the magnificent north entrance gate, the most imposing gateway extant.

Perugia was besieged 40 years B.C. by Octavius Cæsar, and set on fire by the inhabitants. This gateway is undoubtedly Etruscan, and the effect of the fire on the interior of its massive masonry is clearly apparent.

Another gateway was removed by Sangello at the time of making the fortifications (begun 1540); but from the respect that architect seems to have had for its character, he rebuilt it in the walls of the fortress; the jambs of the original gate are visible and in place, within the fortress, and many portions of the palace, towers, houses and streets, which are also built over by the fortifications of that time, remain, so that under the fortress you pass through as it were a subterranean city.

Towers, strong and lofty, were peculiar characteristics of Etruscan cities, and were very numerous, every family of note being compelled to have one. Perugia is said to have had seventy; many remain, diminished in their loftiness in after times compulsorily, Siena has also many of these; and at an ancient town called Gemignano, on the route to Volterra, nearly all its numerous towers remain to their original height, and present a very imposing effect from a distance.

Perugia has maintained its high position in every phase of her existence, and at this time rises superior to every other Etruscan city in her state of modern art and civilization.

Near it is the tomb of the Volunni, an Etruscan family, the monuments of whose members are still preserved in the vault, which is cut out of solid tufo, the ceiling and walls ornamented by sculpture in relief, the last member being a Roman who married into the family.

* * * * *

The ancient usages of the primitive Etruscans appear to have been preserved and followed by the moderns more in Florence and Siena than any other part of Etruria. The modern Florentine braccio, which is the measure of their early masonry, is exactly 2 ancient Roman feet (1 ft. 11 in. of ours), while the braccio of every other Italian state or city is different. It would appear, therefore, that there was some law or reason for the measure, which was so respected by the Romans.

* * * * *

Augustus (who became emperor in the year 30 B.C., and died in the 14th year of the Christian era) boasted to have found Rome *brick* and to have left it *marble;* and we shall find few, if any, *marble* buildings before his time. Most of the temples have been destroyed, or burnt and restored, and to trace what does remain to any period requires the eye of an experienced architect, more than reference to ancient or modern records in writing or tradition, which, however, are great helps in their way.

We know from Strabo, who wrote in the time of Augustus, that the whole of the Campus Martius was covered with fine buildings; and the Mausoleum of Augustus, and the Pantheon, with several other remains on that site corroborate his statement. The Temple of Concord, and *at* the Dioscuri, the noble marble construction of which you see in full sized drawings on the walls, prove the state of architectural construction and sculpture in the Augustan period.

We know that on the Capitol itself there were still nobler buildings, of which nothing remains.

We know that to the northward of the Capitol was a range of magnificent contiguous buildings, the Forum of Augustus, of Trajan, of Nerva, of Paulus Emilius; eastward the Temple of Peace, and of Venus and Rome, the work of Adrian; with numerous other magnificent edifices, raised by the different emperors down to Constantine, whose basilicæ and numerous churches, formed out of ancient buildings, are of much interest; so that the whole area of the city, not only within the walls of Servius Tullius, but extending to those of Aurelian, was covered with them.

As I have described the city walls of Servius Tullius to have been found lately in great extent, of the peculiar sized stones and Isodomum construction, which I have explained, the extent of which was 8 miles, I may briefly mention the nature of the Aurelian walls, which are in their way deserving of notice. They are of brick or tile, and a plan of their disposition is shown. They consist of a thick outer wall, to which are attached buttresses in the inside, arched over and perforated with openings through each. There are towers at distances of about 200 feet, with staircases, so that the warders could give notice of an attack; and a regular communication throughout being formed by the openings, the soldiers could flock to any part for defence. These walls remain for a great part of their extent, which was originally 13 miles."

The following is Strabo's account of Rome, before alluded to:

"'Rome is the first city on the Tiber after Ostia, being placed here not from choice but necessity, it happening that those who increased in some measure the buildings had not the power to locate them in the best places, but were obliged to adapt themselves to what they found; so that the first Romans, having built on the Capitol, on the Palatine, and the Quirinal, left the access to the Capitol so easy, that Titus Tatius coming there to revenge the rape of the Sabine virgins, took it at the first assault. And subsequently Ancus Martius, finding the Celian and Aventine, with the plain between them, divided not only from one another, but also from all the other edifices built there, at first added them, securing them with walls; it then appeared to him not well to leave out of the precinct these hills thus fortified, for which he desired to have some fortress, but he was not able to continue such walls to the Quirinal. Servius supplied this defect, who, completing the walls, added the Esquiline and Viminal hills, and still finding the access of an enemy too easy, he carried a deep 'fosse,' and with workmen throwing the earth inward making an 'Argine' 6 stadii long, and built on the internal edge of the fosse a

Digitized by Google

wall, with its towers, which shut out the space between the Porta Collina and the Esquiline. In the middle of the 'Agger,' there was a third gate called Viminal, from the name of the hill on which it was placed. In this way the fortifications round the city were disposed, which had no other defence, and it appears to me those Romans resolved to do this, as well for their own defence, as that of their posterity, for the Romans obtained security and abundance, not by fortifications, but by their own valour; and they considered that the walls should not defend men, but men defend the walls. Thus finding the fertile and ample space round Rome from the first occupied by strangers, and the lands of the Romans badly secured, they could not expect prosperity in such a position. But having made themselves masters of the above region, they found many benefits surpassing natural advantages, from which cause the city increased to such greatness, containing victuals, wood, and stone for building, so that continually they cut down, burnt, and altered the edifices, so that such change became a voluntary ruin; and rebuilding, according to the fancy of the builders; to this end they obtained wonderful supply of metals, timber, &c., so there were many rivers to convey them. The first river is the Anio, which coming down from Alba, a Latin city near the country of the Marsii, ran through the plain till it joined the Tiber. Then the Naro and the Tenea, which passing by Umbria fell also into the Tiber; and the Clearis, which passes through Tuscany and the Contade of Clusium.

'In order to remedy the defects of the city, Cæsar Augustus used great diligence, ordering the free cohorts to assist the citizens, and to avoid ruins he ordered the height of houses to be reduced, and that along public ways their height should not exceed 70 feet. He would, however, have but little enjoyed these wise arrangements of the city had he not been assisted by metals, timber, and the facility of conveying the materials. These are the facilities Rome receives from the fine nature of the country, to which the Romans added what industry and art could obtain. So that the Grecians being renowned for building, and understanding well the building of walls and gates, and for the selecting of a fertile country and convenient harbours, the Romans instead use study in what the Greeks but little attended to; in that they paved the roads, conducted the water, and by the formation of cloacæ drained the refuse of the city into the Tiber. They paved also the roads into and through the territory, cutting down and levelling the mountains, filling up and raising valleys so that carriages might be made to pass conveying the cargoes of the ships; and made cloache, with vaults of stone, in which a car laden with hay might pass; and such was the abundance of the waters conducted by aqueducts that they appeared like rivers which ran through the city and the cloacæ; and there were few places that had not abundance of reservoirs, conduits, and fountains of water—almost every house provided with water pipes — in which things Marcus Agrippa used great diligence, having with many other ornaments adorned the city.

'Truly, the ancient Romans were so intent on things of the greater consequence, that they cared but little for the *beauty* of the city. But their successors, and principally those of our time, not only were not negligent in this, but filled the city with many and the noblest ornaments.

'Then Pompey, the divine Cæsar Augustus, his sons, his friends, his wife, and sister, have lavished the greatest study and expense they could use in these embellishments. Of that there is proof in the Campus Martius, which besides the amenity of its situation is gifted with artificial ornaments, so that its size offers free space to the immense multitude which resort there to amuse themselves with the games of races of cars and horses, of the "Palla" in the circus, and wrestling. Then the buildings which surround it, the herbage which continually covers it, and the hills which crown it in the part opposite the river, occasion such a spectacle that strangers can scarcely tear themselves away from us. Near this field you also find another, with many porticoes around, sacred groves and woods, three theatres, an ampitheatre, and sumptuous temples, one following the other so closely, that this would appear an adjunct to the city itself. Besides considering the spot especially sacred, sepulchres of the most illustrious men and women were placed there, among which the most celebrated is that which is called Mausoleo, built on a high base of solid stone, near the banks of the river, and wholly shaded up to the summit by evergreen trees, on the top is the statue of Cæsar Augustus in bronze, and on the banks are sepulchres of himself, his parents, and household. At the back is a large wood, with marvellous roads for enjoyment. In the middle of the field there is an enclosed place in which the body of Augustus was burnt after his death, and this also is of white stone and surrounded by cancelli of iron, and in the inside many poplar trees. Then if the stranger entering into the Ancient Forum would consider the correspondence with each other of the various buildings, the porticoes and the temples, and contemplate the Capitol, with the works which are raised there, as well as those situate on the Palatine, and on the Portico of Livia, he would easily forget external objects,'

Such was Rome, a little after the death of Augustus, when Strabo visited it. Afterwards it was much more adorned by more grandiose and magnificent edifices, that rendered it certainly superior to all the other cities under the dominion of the Romans in other regions."

The remainder of the book is occupied by a description of such of the *marble* buildings left us as are interesting or instructive, and among them will be found the temples of Mars Ultor, Jupiter Stator, Concord, Jupiter Tonans, Antoninus and Faustina, Neptune, Venus and Rome, and Vesta; the Pantheon, the Forum of Nerva, and the columns of Trajan, Antoninus Pius, Marcus Aurelius Antoninus, and Phocas.

Recreative Science: a Monthly Record and Remembrancer of Intellectual Observation.—London: Groombridge and Sons.

This is a remarkably pleasing and useful little work, which professes to treat of subjects the most attractive in all branches of science; and, so far as we can judge from the first two numbers, it will prove a valuable addition to the stock of information that is now presented in various forms with a view to promote a taste for scientific knowledge, which has until recently been so much neglected in the education of youth. Among the variety of subjects that are here noticed, in a very readable form, there is an account of Dr. F. Johann Fuch's invention of waterglass, a material that promises to have extensive uses in the arts. Though its application to photography is principally dwelt upon, other valuable applications of waterglass are noticed, and among them the service it is likely to render to architecture by affording a protection to the surface of brick and stone from the action of the atmosphere. We quote the following passages bearing on this subject; commencing with a description and properties of waterglass:—

"Let us now see if we can get a closer philosophical insight into this strange and useful thing, soluble glass, or tetra-silicate of either potash or soda. Its essential basis is the *non-metallic* element, silicon—or silicium, as it has been called by some, from its supposed metallic nature. Berzelius described silicon to be a brown powder, and judging of it in this condition, he compared it with carbon and boron, two other non-metallic elementary bodies. However, as aluminium, the new white metal, the basis of alumina and of clay, turned out to be metallic, it might be that silicon, the basis of silica, would also have to be classed with the metals. The researches of the distinguished French chemist, M. Deville, on aluminium, have, however, led to the production of many-sided crystalline plates of silicon, translucent and nearly colourless, not having any of the ordinary metallic properties. We must now therefore, view silicon as a non-metal, and group it with boron and carbon, to which it has several points of resemblance.

This silicon, obtained by the action of aluminium and heat on siliceous materials, burns in oxygen gas to form a white powder, the oxide of silicon, or silica, or silicic acid, as it is variously termed. Pure rock crystal, opal, beryl, chalcedony, hornstone, jasper, quartz, flint, sand, part of all clays, &c., consist of this silica or silicic acid; indeed, it is one of the most abundant things in nature, as may be at once observed from this description of it. It is in one state soluble in water, and is found in parts of plants, animals, and animalcules, and notably in the canes, grasses, and stalks of cereals. This silica, or pure flint, fuses under the oxyhydrogen blowpipe to a clear bead; when fused it may be drawn out into long threads like glass; dropped in a state of fusion into water it solidifies to a transparent mass, free from flaws, and remarkably hard and tough, so that it sustains the blow of a hammer without breaking. It seems to harden like steel by sudden cooling. Silica can be evaporated from solution by steam. The Geyser tubes of Iceland owe their formation to the fact of the possible solubility and volatility of silica, joined to its peculiar power of losing this solubility under fresh circumstances. Silica is tasteless, inodorous, and, though chemically an acid, is without action on vegetable colours. It can, under certain conditions, combine with water to form a hydrated siliceous jelly. The soluble form of silica, obtained by precipitation from a silicate, loses its solubility by simple evaporation at a boiling heat, or little more. The varied and remarkable properties of silica must undoubtedly lead to further applications in practical manufacturing hands. The waterglass is the main door by which a practical man may best enter.

The silicic acid, or silica, being understood to be an acid, we can now see at once that, like other acids, it may form "salts." Soap is a stearate of soda—stearic acid and soda. This salt is miscible with water, while the acid of the salt, the fat, is not. So, in the same way, silicic acid, in its insoluble form, is made miscible with water by means of an alkali—potash or soda. In both cases stronger agents can throw out the combined acids, and, as we shall see, in the the case of waterglass, with novel and highly useful results. Even bodies not acid, as sal ammoniac, etc. can throw down the silica under useful conditions; but the scientific details and marvels of silica are exhaustless, and the eager student must pursue them further in Gmelin and the authors already named.

And now, in conclusion, to consider some of the applications of silica in the form of waterglass to the arts. First, as most interesting to us, it is proposed to make careful photographic experiments, with varieties of waterglass, adding more or less silica, as may be deemed fit. Waterglass has been also proposed (and is undergoing fair trial), in order to protect building stones from decay. The expectation is that waterglass, applied as a wash, will have its silica deposited by atmospheric carbonic acid, in minute adherent particles, upon the surface of the stone, which will thus

Digitized by Google

be shielded by a flinty substance from the acids which smoky rain brings down in large towns; and where carbonate of lime exists in the building stone, a further action is expected from the formation of an insoluble silicate of lime, another protective agent. The decaying surfaces in the cathedral of Notre Dame in Paris, the new Houses of Parliament at Westminster, and many other similar buildings, have been thus treated. Then it has been proposed to mix soluble glass with mortars, to enable them to set under water, by virtue of the insoluble silicates, which would form under circumstances of contact between waterglass and the materials used. Another and very important (for the fine arts) application is in the *stereochrome system* of *painting*, invented by Fuchs, and worked out successfully by Kaulbach in Germany, and Kuhlmann at Lille. The principle is to prepare a surface of cement or stone or slate in a manner proper to receive *dry colours*, and then to fix these colours on the wall or surface by means of a varnish of the soluble glass, which is syringed on, and left to dry. In a short time the carbonic acid of the air and the earths in the surface throw down the silica, or flint, the alkali partly combining; or it effloresces out, and is easily washed off, the picture remaining adherent, and only removable by mechanical disintegration. Experiments made in exposed places, as to weather, have proved to be perfectly successful. A crucial experiment was made at Berlin by suspending a stereochrome painting for twelve months in the open air, under the principal chimney of the New Museum at Berlin. During that time it was exposed to sunshine, mist, snow, and rain, and nevertheless retained its full brilliancy of colour."*

PHOTOGRAPHIC ILLUSTRATIONS FOR BOOKS.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—Being much interested in the above subject, I read with interest Professor Smyth's paper in your last number, p. 287.

To the question, asking "on whom the blame was to fall when any of the printing or original negatives got broken?" the professor no doubt has given the best answer,—that others only should be printed from, but even these others being liable to damage or destruction being also admitted, it may not be amiss to notice an invention by a person named Quin about twenty-five years since, for printing from engravings on slate in the ordinary printing press, as copperplate engravings are now printed from. This invention, without which the slate engravings would have been useless, consisted in embedding the slate in a strong timber case, in a bituminous elastic cement.

I never saw the Mr. Quin who effected the invention, but having a number of duplicates to produce of engineering designs, where at the time it was not possible to have the aid of even good lithography, I called on the brother of Mr. Quin, then a coachmaker in Limerick, and he gave so clear an account of the whole process, that we not only engraved the designs upon good Bangor or Killaloe slate rubbed down smooth, but we were able with a lever press and roller to print off the copies required, without in any case breaking one of the slates. Such a provision would no doubt effectually secure the second negatives, and thus obviate the delay and disappointment that might otherwise arise.

I heard from Mr. Anthony Quin, the brother of the inventor, that the latter had been awarded a gold medal—I believe by the Society of Arts. I shall be happy to afford any further information.

J. W—K.

17*th September*, 1859.

NEW CHURCH, FRAMINGHAM PIGOT, NORFOLK.

THE old and dilapidated church of Framingham Pigot, near Norwich, has, through the munificence of Mr. G. H. Christie, been replaced by one of the most beautiful structures to be found in the county. Some time ago the chancel was rebuilt by this gentleman, who has now completed the work, at an outlay of upwards of £5000.

The new edifice, which is in the Early Decorated style, and the details of which are most elaborate, consists of a nave and chancel, with accommodation for 300 persons, being twice the capacity of the old structure. The church is faced with flint, with Ancaster stone dressings. The pillars of the western door are composed of Serpentine marble from Cornwall, and over the centre of the archway is carved a figure of St. Andrew, with two angels holding the crown of glory over his head, and another above bearing the St. Andrew cross, while at each side an angel is bending in adoration. The doorway has a gable end, with two angels at the springing of the gable, which is terminated by a richly carved finial. The figures of this porch were carved by Mr. Samuel Ruddock, of London. At the south-west there is another porch, which projects some distance, and is arcaded, and contains a very elaborate doorway; there is also a small porch on the same side leading into the chancel. The doors, like all the wooden fittings of the church, are of oak, with iron hinges of an elaborate pattern. At the west end is a stained glass window, by Messrs. King, of Norwich. The tower, which is 112 feet high, and surmounted by a foliated cross of gilt copper, is built of Ketton rag and Ancaster stone: it is square to the height of 58 feet, with angle buttresses, and a staircase turret leading to the clock chamber: above this is a lantern 14 feet high, on which the spire ascends to a height of 36 feet. The dial of the clock is of stone, and richly carved. The roof of the church is of stained wood, and the floor is paved with Minton's encaustic tiles. The altar rail is of burnished brass and ironwork painted blue. The seats are all of carved oak, and there are some finely carved stalls intended for the choristers on each side of the west door. On the north side of the church is the organ gallery, supported on polished pillars, surmounted by a stone screen. The pulpit, of solid oak arcaded, is on the north side, between the chancel and the church, and is entered through an arched doorway in the wall. The reading desk, also of oak, and carved in open arcades, is situated on the other side. Mr. Lloyd, of Norwich, was the builder employed.

OBSERVATIONS ON THE ANTIQUITY OF THE HUMAN RACE.

By Sir CHARLES LYELL, F.R.S.

IN the course of his address, delivered on the 16th ult. at Aberdeen, as president of the Geological Section of the British Association, Sir Charles Lyell stated the result of some observations made in France on the proofs of the antiquity of the human race, of which we give the following abstract:—

No subject has lately excited more curiosity and general interest among geologists and the public than the question of the antiquity of the human race; whether or no we have sufficient evidence to prove the former co-existence of man with certain extinct mammalia, in caves or in the superficial deposits commonly called drift or "*diluvium*." For the last quarter of a century the occasional occurrence in various parts of Europe of the bones of man, or the works of his hands, in cave-breccias and stalactites, associated with the remains of the extinct hyena, bear, elephant, or rhinoceros, have given rise to a suspicion that the date of man must be carried further back than we had heretofore imagined. On the other hand, extreme reluctance was naturally felt on the part of scientific reasoners to admit the validity of such evidence, seeing that so many caves have been inhabited by a succession of tenants, and have been selected by man as a place not only of domicile but of sepulture, while some caves have also served as the channels through which the waters of flooded rivers have flowed; so that the remains of living beings which have peopled the district at more than one era may have subsequently been mingled in such caverns, and confounded together in one and the same deposit. The facts, however, recently brought to light during the systematic investigation, as reported on by Falconer, of the Brixham Cave, must, I think, have prepared you to admit that scepticism in regard to the cave-evidence in favour of the antiquity of man had previously been pushed to an extreme. To escape from what I now consider was a legitimate deduction from the facts already accumulated, we were obliged to resort to hypothesis requiring great changes in the relative levels and drainage of valleys, and, in short, the whole physical geography of the respective regions where the caves are situated,—changes that would alone imply a remote antiquity for the human fossil remains, and make it probable that man was old enough to have co-existed at least with the Silurian mammoth. But in the course of the last fifteen years another class of proofs has been advanced in France in confirmation of man's antiquity, into two of which I have personally examined in the course of the present summer, and to which I shall now briefly advert. First, so long ago as the year 1844, M. Aymard, an eminent palæontologist and antiquary, published an account of the discovery in the volcanic district of central France of portions of two human skeletons (the skulls, teeth, and bones), imbedded in a volcanic breccia

* For particulars of Dr. J. Fuch's methods of preparing and applying waterglass, see *ante*, p. 215.

Digitized by Google

found in the mountain of Denise, in the environs of Le Puy en Velay, a breccia anterior in date to one at least of the latest eruptions of that volcanic mountain. On the opposite side of the same hill the remains of a large number of mammalia, most of them of extinct species, have been detected in tufacious strata, believed, and I think correctly, to be of the same age. The authenticity of the human fossils was from the first disputed by several geologists, but admitted by the majority of those who visited Le Puy, and saw with their own eyes the original specimen now in the museum of that town. Among others M. Pictet, so well known to you by his excellent work on palæontology, declared after his visit to the spot his adhesion to the opinions previously expressed by Aymard. My friend, Mr. Scrope, in the second edition of his 'Volcanoes of Central France,' lately published, also adopted the same conclusion, although, after accompanying me this year to Le Puy, he has seen reason to modify his views. The result of our joint examination, a result which I believe essentially coincides with that arrived at by M. Hébert and M. Lartet, names well known to science, who have also this year gone into this inquiry on the spot, may thus be stated. We are by no means prepared to maintain that the specimen in the museum at Le Puy (which unfortunately was never seen *in situ* by any scientific observer) is a fabrication. On the contrary, we incline to believe that the human fossils in this and some other specimens from the same hill were really imbedded by natural causes in their present *matrix*. But the rock in which they are entombed consists of two parts, one of which is a compact and for the most part thinly laminated stone, into which none of the human bones penetrate; the other, containing the bones, is a lighter and much more porous stone, without lamination, to which we could find nothing similar in the mountain of Denise, although both M. Hébert and I made several excavations on the alleged site of the fossils. M. Hébert therefore suggested to me that this more porous stone, which resembles in colour and mineral composition, though not in structure, parts of the genuine old breccia of Denise, may be made of the older rock broken up and afterwards redeposited, or as the French say, "*remanié*," and therefore of much newer date. An hypothesis which well deserves consideration; but I feel that we are at present so ignorant of the precise circumstances and position under which these celebrated human fossils were found, that I ought not to waste time in speculating on their probable mode of interment, but simply declare that in my opinion they afford no demonstration of man having witnessed the last volcanic eruptions of central France. The skulls, according to the judgment of the most competent osteologists who have yet seen them, do not seem to depart in a marked manner from the modern European or Caucasian type, and the human bones are in a fresher state than those of the *elephas meridionalis* and other quadrupeds found in any breccia of Denise which can be referred to the period even of the latest volcanic eruptions.

But while I have thus failed to obtain satisfactory evidence in favour of the remote origin assigned to the human fossils of Le Puy, I am fully prepared to corroborate the conclusions which have been recently laid before the Royal Society by Mr. Prestwich, in regard to the age of the flint implements associated in undisturbed gravel, in the north of France, with the bones of elephants, at Abbeville and Amiens. These were first noticed at Abbeville, and their true geological position assigned to them, by M. Boucher de Perthes in 1849, in his 'Antiquités Celtiques,' while those of Amiens were afterwards described, in 1855, by the late Dr. Rigollot. For a clear statement of the facts I may refer you to the abstract of Mr. Prestwich's memoir in the Proceedings of the Royal Society for 1859, and have only to add that I have myself obtained abundance of flint implements (some of which are laid upon the table) during a short visit to Amiens and Abbeville. Two of the worked flints of Amiens were discovered in the gravel-pits of St. Acheul—one at the depth of 10 feet and the other 17 feet below the surface—at the time of my visit; and M. Georges Pouchet, of Rouen, author of a work on the 'Races of Man,' who has since visited the spot, has extracted with his own hands one of these implements, as Messrs. Prestwich and Flower had done before him. The stratified gravel resting immediately on the chalk, in which these rudely fashioned instruments are buried, belongs to the post-pliocene period, all the fresh-water and land shells which accompany them being of existing species. The great number of the fossil instruments, which have been likened to hatchets, spear-heads, and wedges, is truly wonderful. More than a thousand of them have already been met with in the last ten years in the valley of the Somme, in an area 15 miles in length. I infer that a tribe of savages, to whom the use of iron was unknown, made a long sojourn in this region; and I am reminded of a large Indian mound, which I saw in St. Simond's Island, in Georgia—a mound 10 acres in area, and having an average height of 5 feet, chiefly composed of castaway oyster shells, throughout which arrow-heads, stone axes, and Indian pottery are dispersed. If the neighbouring river, the Alatamaha, or the sea which is at hand, should invade, sweep away, and stratify the contents of this mound, it might produce a very analagous accumulation of human implements, not unmixed perhaps with human bones. Although the accompanying shells are of living species, I believe the antiquity of the Abbeville and Amiens flint instruments to be great indeed if compared to the times of history or tradition. I consider the gravel to be of fluviatile origin, but I could detect nothing in the structure of its several parts indicating cataclysmal action, nothing that might not be due to such river-floods as we have witnessed in Scotland during the last half century. It must have required a long period for the wearing down of the chalk which supplied the broken flints for the formation of so much gravel at various heights—sometimes 100 feet above the present level of the Somme—for the deposition of fine sediment, including entire shells, both terrestrial and aquatic, and also for the denudation which the entire mass of stratified drift has undergone, portions having been swept away, so that what remains of it often terminates abruptly in old river cliffs, besides being covered by a newer unstratified drift. To explain these changes I should infer considerable oscillations in the level of the land in that part of France—slow movements of upheaval and subsidence, deranging, but not wholly displacing, the course of the ancient rivers. Lastly, the disappearance of the elephant, rhinoceros, and other genera of quadrupeds now foreign in Europe, implies in like manner a vast lapse of ages, separating the era in which the fossil implements were framed and that of the invasion of Gaul by the Romans.

Among the problems of high theoretical interest which the recent progress of geology and natural history has brought into notice, no one is more prominent, and at the same time more obscure, than that relating to the origin of species. On this difficult and mysterious subject a work will very shortly appear by Mr. Charles Darwin, the result of twenty years of observation and experiment in zoology, botany, and geology, by which he has been led to the conclusion that those powers of nature which give rise to races and permanent varieties in animals and plants, are the same as those which in much longer periods produce species, and, in a still longer series of ages, give rise to differences of generic rank. He appears to me to have succeeded, and by his investigations and reasonings to have thrown a flood of light on many classes of phenomena connected with the affinities, geographical distribution, and geological succession of organic beings, for which no other hypothesis has been able, or has even attempted, to account.

Among the communications sent into this section, I have received from Dr. Dawson, of Montreal, one confirming the discovery which he and I formerly announced of a land shell, or pupa, in the coal formation of Nova Scotia. When we contemplate the vast series of formations intervening between the tertiary and carboniferous strata, all destitute of air-breathing mollusca, at least of the terrestrial class, such a discovery affords an important illustration of the extreme defectiveness of our geological records. It has always appeared to me that the advocates of progressive development have too much overlooked the imperfection of these records, and that, consequently, a large part of the generalisations in which they have indulged in regard to the first appearance of the different classes of animals, especially of air-breathers, will have to be modified or abandoned. Nevertheless, that the doctrine of progressive development may contain in it the germs of a true theory, I am far from denying. The consideration of this question will come before you when the age of the white sandstone of Elgin is discussed, a rock hitherto referred to the old red or Devonian formation, but now ascertained to contain several reptilian forms of so high an organisation, as to raise a doubt in the minds of many geologists whether so old a place in the series can correctly be assigned to it.

Digitized by Google

NEW SHIP'S WINDLASS.

LATELY a trial was made on board the Newcastle, of 1200 tons, in the East India Dock, belonging to the Messrs. Green, of a patent ship's windlass, which it is thought will produce important results as regards the mercantile marine. The patent windlass exhibited on this occasion was originally an American invention, and is stated to have been applied very successfully to a number of vessels on the other side of the Atlantic; and, considerable alterations having been made in this country to improve and strengthen it, Messrs. Emmerson and Walker, the patentees of the invention in its new form, now submit it to the judgment of experience. It may be added that the Newcastle is not the only vessel which will soon afford an opportunity of working it; Messrs. Somes Brothers' new ships at Dundee and Glasgow are also being provided with it. The peculiarity of this windlass consists in its being a combination of the capstan and windlass, and in an ingenious arrangement of the parts, by which either a very heavy purchase or a quick motion may be had at will, simply by turning the capstan round, with the sun in the one case, and in the other against it. The two ends of the windlass which take the chain can either or both be placed in connection with the capstan, and the result is that one chain only or two at one time can be worked with equal facility. The chains, it is stated, require no fleeting, but are drawn directly from the lockers, are not liable to surge, and can be paid out, checked, or stopped at any moment, by one man at the break. The windlass is simple in its construction, and so compact that in the Newcastle it occupies only a space of 7 ft. 6 in. by 4 ft. 6 in. Combined with the windlass were seen Wardill's patent chain compressors or stoppers, by means of which one man will, it is anticipated, always be able to keep the cable under perfect control. During the visit paid to her the Newcastle's anchor was lifted, and the economy of labour was shown by the fact that twelve men, or about half the usual number of hands for an anchor of the same dimensions, were sufficient for the operation, the saving in time being far more than proportionate to that in labour. The importance of the invention in this point of view is enhanced, so far at least as the Newcastle is concerned, by that vessel being provided with Cunningham's patent topsails—an invention which substitutes for the tedious and dangerous operation of reefing by hand a self-acting process of great simplicity and rapidity. The difficult operations of lifting and lowering the anchor, and of reefing topsails, have hitherto necessitated the employment of a much larger crew than were necessary for the ordinary duties of seamanship; and hence, if these two inventions shall receive the sanction of nautical experience, they may possibly lead to a reconsideration of the number of hands which each vessel shall be compelled to have in proportion to the tonnage. Even if the legislature should consider any reduction of the number undesirable, on account of the many unforeseen emergencies of sea-life, that can be no reason for not adopting or encouraging the aids of mechanical invention, or for retaining slow and cumbrous processes in place of rapid and simple ones. As the Newcastle will shortly sail for India, the merits of the new windlass in practice will, no doubt, ere long be duly reported upon by her officers.

DISINFECTION OF SEWAGE.

THE following letter, addressed to the editor of the *Daily News*, gives the result of some experiments on M'Dougall's disinfecting powder:

"Sir,—The present state of the Thames has become so dangerous to the whole community, that it has for some time drawn the attention of the authorities to the consideration of some plan by which its action may be prevented. Hence experiments have been made with various disinfectants, at the request of the Metropolitan Board of Works, by Professor Miller, of King's College. What the results are at which he has arrived I have no exact means of knowing, but having for years experimented with various disinfectants, and having drawn the attention of the public to the effects produced—(you yourself having once granted me the use of your valuable space for the purpose)—I would ask your consent to publish my experience upon the sewage in the present year.

It may be as well to state that my results last year were so entirely in favour of the disinfectant of Messrs. Smith and M'Dougall, of Manchester, that I was induced early in the present year to repeat them. I again found that sewage of the worst description, emitting the most deleterious gases, could be rendered perfectly sweet and harmless, emitting only the odour of the impure coal-creosote (carbolic acid) which forms the important feature of Dr. Smith's invention. Whenever a sufficient quantity of the disinfecting powder was employed, I found that sewage precipitated in May was perfectly free from sewage odours in July; and sewage deposit, which is the worst part of sewage, when similarly dealt with, remains to this day equally beneficially affected. Comparing these results with those I published last year; and especially comparing the disinfected specimens with one which I have had these three years (last June) in my possession, and finding the results perfectly in concordance, it cannot be wondered that the patentees, with a knowledge of these facts, should have desired me to make notes of any experiments which might be made under the direction of the Board of Works. Accordingly I have done so, and subjoin such results as I have arrived at. According to Dr. Miller's suggestion, Mr. M'Dougall employed a portion only of his patent, viz., that which embraces the use of carbolic acid and lime. Although I am of opinion that these include the most valuable part of Dr. Smith's discovery, yet I cannot but think that the whole patent, which involves the additional employment of sulphate of lime and magnesia, is better suited to effect the object, viz., prevention of the decomposition of both animal and vegetable matter. However this may be, the results of the large experiment on the Tottenham-court-road sewer are sufficiently satisfactory to warrant a similar application to the Thames.

The quantity of carbolic acid employed in the above sewer averaged 685 lb. (at 6*s.* 6*d.* per cwt.) per day, together with 70 lb. of lime and 12,000 gallons of water. On the hottest days a larger amount appeared necessary, as I judge from the results; at least this is certain, that when another cwt. or so was employed in excess of the above 685 lb. the sewage bore the highest temperature to which it could ever be exposed under the highest conceivable solar influences, continued for six days, without evolution either of sulphuretted hydrogen or any other foul emanation.

I will not ask you to publish each experiment, but will merely record that the clear amber-coloured solution of carbolate of lime was churned by paddles into an opening in the sewer in Tottenham-court-road, and that the specimens examined by me were the precise counterparts of those which Dr. Miller received.

The conclusions arrived at were, that it was quite within the reach of possibility to prevent altogether the evolution of nauseous gases from London sewage, and not difficult to disinfect the Thames. But if price is a consideration, I cannot understand how any other disinfectant can be employed. The experiments made with chloride of lime distinctly indicate that, unless in actual excess, which would involve six times the outlay, the sewage becomes almost as bad as before its addition. Effective, too, as is Cundy's, a similar objection applies both as to price and continuous results. If then, as I am entitled to conclude from very many experiments, it is possible to prevent the Thames from continuing year after year the most dangerous nuisance, by the judicious application of Messrs. M'Dougall's disinfectant, it becomes simply a question of proportions and price. The latter I would not attempt to fix, as my data are at present insufficient; but the proportions admit of scientific calculation. The mode of appliance is fortunately at hand. Not contented with disinfecting the sewage, we must at once direct attention to the Thames. By diffusing the disinfectant with the aid of the paddles of the numerous steamers which are constantly stirring up the mud of the river, we have a method which would ensure complete success in purification in the course of a week.

But whether or not such a plan be adopted, no effectual good can be done by driblets. The expenditure of £1500 per week in lime and chloride of lime at the mouths of the sewers is perfectly useless, and will accomplish nothing towards preventing the rise of deadly miasmata from the body of the river.—I am, &c.

ALBERT J. BERNAYS,
Lecturer on Chemistry at St. Mary's Hospital, Paddington."

Coal Discovered in Kent.—While the workmen employed on the London, Chatham, and Dover Railway were engaged in tunnelling between Lydden-hill and Shepherds-well, near Dover, they came upon a fine seam of coal, and what is most remarkable, the coal is on all sides surrounded with chalk, with the usual seams of flint as are seen on the cliffs at Dover. The more the seam is entered upon the better becomes the quality of the coal.

Digitized by Google

THE EVAPORATIVE POWER OF WELSH AND NEWCASTLE COAL;—AND THE COST PER HORSE-POWER OF VARIOUS PUMPING ENGINES.*

The evaporative power of eight descriptions of Welsh coals and four of small Newcastle coals, as ascertained by Mr. Wicksteed, are given in the following table. The Welsh coals were bought in the market for the purpose of ascertaining their evaporative power, and the order was given for the best coals of the kind, without limit to price; the small Newcastle coals were not selected specially, but were the best coals in the market, were ordered without reference to price, but the names were not recorded.

The quantity of Welsh coals tried was 111 tons, and of small Newcastle 460 tons; the temperature of the water supplied to the boilers was 80°. The proportion of clinker and ashes in 74,760 lb. of small Newcastle coals, and in 11,895 lb. of Welsh anthracite coals, were ascertained to be equal to 6 per cent. in the former, and 9 per cent. in the latter.

		Quantity in pounds.	Water evaporated per lb. of coals from 80°.
Welsh coals.	Pentre coals from the heap	98,420	7·514
	Eaglebush ,, ,,	30,576	7·155
	Pentre and Eaglebush coals from the heap, mixed in equal parts	22,260	7·960
	Llanelly coals from the heap	9,612	7·436
	Graigola ,, ,,	11,340	7·499
	Llangynneck ,, ,,	11,200	7·637
	Oakwood, bituminous ,,	31,864	7·963
	Merthyr coals from the heap	29,652	9·493
	Anthracite ,, ,,	13,832	9·014
	Total	248,756	7·963 mean
Small Newcastle coals.	First kind tried	379,176	7·678
	Second ,, ...	161,588	8·524
	Third ,, ...	95,060	8·137
	Fourth ,, ...	402,052	7·958
	Total	1,037,876	8·074 mean

The chief object of these trials was to ascertain the effect, per pound sterling, of Welsh and Newcastle coals, at the price in "the Pool," and the facts recorded above proved that the market price of coals was no criterion of their value—as the price of the Welsh coals delivered in London was much higher than the Newcastle coals—and this was in fact the reason of less quantities (although large for the purpose intended) of Welsh coal being tried than of Newcastle.

The author's experience has led him to the conclusion that for commercial, practical, or useful purposes, much greater reliance is to be placed upon results obtained from the consumption of large quantities of coals, consumed under good boilers in ordinary use, and well stoked, than upon results obtained from small quantities of selected coals consumed in the course of a few hours under a boiler erected specially for the purpose of experiment, or from laboratory experiments.

The following table shows the pounds of coals consumed per horse-power per hour, the price per ton of the coals used, and the actual cost (at the dates given in the table) of coals, stores, and labour per horse-power per annum, of several engines, working at the rate of twelve hours per diem, six days per week. To the East London Water-works engines, those belonging to the Hull Corporation, the Vauxhall, Kent, and Grand Junction Water-works Companies (at the dates given in the table), are added. The two double-acting engines at Hull were not in good order, and were very badly arranged; the two direct action single-acting engines, with low-pressure steam, and waggon-head boilers, were good engines, made by the late Mr. Joseph Whitham, of Leeds; the two double-acting engines at Vauxhall were made by Messrs. Fenton, Murray, and Wood; the two single-acting engines at the Kent, and two of the single-acting engines at the Grand Junction Water-works, Kew, were made by Boulton and Watt; and the third engine at the Grand Junction was made by Messrs. Maudslay and Field. The author obtained the data for this table during the period he acted as consulting engineer to the several parties. The Vauxhall Water-works were amalgamated with the Southwark Water-works by the advice of the author, and at the amalgamated works, and also at the Grand Junction, Kent, and Hull Works, Cornish engines have been erected since the dates given in the table.

	lbs. of coals per horse-power.	Price per ton.	Cost of coals per annum.	Cost of stores per annum.	Cost of labour per annum.	Total cost per annum per horse-power.
		s. d.	£	£	£	£ £ s. d.
1. The Hull Water-works, two double engines, 1845	23·75	7 3½	14·468	2·351	5·991	22·810 or 22 16 2½
Two direct action, 1847	6·10	,,	3·723	1·361	3·800	8·884 ,, 8 17 8
2. The Vauxhall Water-works, two double engines, 1843 and 1844	11·50	11 4½	10·973	1·391	4·419	16·783 ,, 16 15 8
3. The Kent Water-works, two single-acting, 1834	8·81	22 1	16·310	2·188	3·810	22·308 ,, 22 6 2
4. The Grand Junction, three single-acting, 1843, 1844, and 1845	7·49	18 5	11·568	1·327	2·537	15·432 ,, 15 8 8
5. The East London Water-works, four single-acting, 1830 ...	8·90	16 10	12·566	1·654	2·102	16·322 ,, 16 6 5
Ditto Ten years, from 1831 to 1840...	7·60	18 5	11·738	1·195	2·060	14·993 ,, 14 19 10
Ditto Ten years, from 1841 to 1850, two engines	6·20	12 11½	6·737	1·096	2·086	9·919 ,, 9 18 4½
Ditto Two Cornish engines, the two averaging seven years, to 1850	2·99	11 8½	2·933	0·784	1·852	5·569 ,, 5 11 4½

It should be observed that although the coals and stores are, or should be, in proportion to the horse-power, and hours worked, the labour will vary,—as it would require no more labour to work an engine of 100 horse-power than one of 50, although the cost per horse-power would be twice as great in the latter case, and as the varying prices of a ton of coals are not in proportion to the quality of the coals, the practical value of the above table is limited in this instance, as in many others met with in practice,—in fact, each case and each locality may lead to a variation in the cost per horse-power, notwithstanding the engine may be equally good in principle and construction; to the experienced man, however, it may be useful as a statement of ascertained facts, and may assist in estimating the cost per horse-power per annum.

* From 'Further Elucidations of the Useful Effects of Cornish Pumping Engines.' By Thomas Wicksteed, C.E. London: Weale. 8vo. 1859.

THE LATE MR. BRUNEL, C.E., F.R.S.

Isambard Kingdom Brunel was the only son of the late Sir Mark Isambard Brunel, the engineer of the Thames Tunnel. He was born in the year 1806 at Portsmouth, where his father was engaged in erecting the block machinery for the Government Dockyard. He was sent at a very early age to the engineering college at Caen, and devoted himself to the study of mathematics and the applied sciences. At the age of twenty he entered on the life of a scientific engineer. His father was now engaged upon the construction of the Thames Tunnel, and the son established speedily a professional reputation by his able assistance of the scheme.

The special objects of Mr. Brunel's study were mechanical and railway engineering, and the construction of machinery for locomotives and steam navigation, though he devoted no less than ten years of patient perseverance to the experiments made by his father to test the applicability of carbonic acid gas as a

Digitized by Google

motive power to engines of various kinds. These experiments, as is well known, were unsuccessful; not because the father and the son, by their combined energy, did not overcome the mere mechanical difficulties which stood in their way, but on account of the expense which would be involved by the substitution of carbonic acid gas for steam.

In 1830, Mr. Brunel was elected a Fellow of the Royal Society. In 1833 he was appointed chief engineer to the Great Western Railway, then first projected, the whole of which line, including the arches, viaducts, and tunnels, was constructed from his designs or under his direction. The Maidenhead bridge over the Thames, the viaduct at Hanwell, the Box tunnel, the bridge over the Wye at Chepstow, and that over the Tamar at Devonport, having a central pier founded 80 feet below the water, owe their origin to his genius. The same may be said of the South Devon and Cornish Railways, with their famous sea-wall. In the celebrated "battle of the gauges" he supported the claims of the "broad guage," but unsuccessfully. Mr. Brunel was also largely engaged as a civil engineer upon the construction, remodelling, extension, and improvement of very many of the docks at our largest outports. The most important of these are the Bute Docks at Cardiff, and the old North Dock at Sunderland. In 1842 he was employed by government to construct the Suspension-bridge across the Thames at Hungerford. He was not only the engineer, but the designer, of the Great Western steam ship. Its power and tonnage were double that of any which had previously been built. The Great Britain, framed upon the principle of extending the use of iron in the making of ships, in respect of tonnage was double that of the Great Western herself. His greatest effort and his last was the Great Eastern.

Among the most important of Mr. Brunel's achievements was his discovery of the use that might be made of the screw as a propeller. He decided upon the application of the principle to steamships. The full practical value of the alteration will not be fully known till the next war, when the merits of the screw will be tested under fire. It was under Mr. Brunel's auspices that the first screw-ship in the British navy was fitted up. In 1850 he undertook the Tuscan portion of the works of the Sardinian railway, which he completed in 1853. During the Crimean war he was appointed to reorganise the Renikoi hospitals, upon the Dardanelles. The entire arrangement of the buildings was subjected to his supervision. Water was laid on from the neighbouring hills, and invalid carriages soon ran on little railroads from the shore into the very wards of the institution.

On his return from Turkey, Mr. Brunel's energies were mainly devoted to the construction of the Great Eastern steamer, which he originally projected jointly with Mr. J. Scott Russell. He succeeded in accomplishing this great task at an expenditure of money, labour, and material unprecedented in the annals of shipbuilding. But the mechanical difficulties and the moral responsibilities of the gigantic undertaking were too great a strain for a health already enfeebled by exertion. At the age of fifty-three he was a worn-out man.

He was chosen a member of the council of the Royal Society in 1844. He was also one of the vice-presidents of the Institution of Civil Engineers, and of the Society of Arts; a Fellow of the Astronomical, Geological, and Geographical Societies; and a Chevalier of the Legion of Honour.

Isambard Kingdom Brunel died on the 15th ult., at his town residence, 17, Duke-street Westminster, and was buried at Kensall-green Cemetery.

NOTES OF THE MONTH.

New Opera House, Rio De Janeiro.—Some time since the architects of all countries were invited by the Brazilian government to send in designs for a new Opera House, to be erected on a grand scale at Rio de Janeiro. Three premiums of considerable value were promised to the most successful of the competitors. The result has just been announced, and it is rather noteworthy. Five-and-twenty architects responded to the invitation. The first premium, of the value of about £2250, was awarded to Gustavo Waenheldt, of Rio Janeiro. The second premium, of £900 value, was gained by Messrs. Green and Deville of London, and the third of £450, by Mr. S. Sloan of Philadelphia. This appears to be a somewhat curious distribution; an exhibition of the designs would be worth visiting.

New Horticultural Garden at Kensington Gore.—A model, showing how the ground will be laid out in terraces for the garden of the Horticultural Society, has just been placed in the South Kensington Museum, at the north end, near to the entrance to the ornamental art rooms. Between the Kensington-road and Cromwell-road the ground falls about 40 feet, and using this fact in aid of a general effect, the ground has been divided into three principal levels. The entrances to the gardens will be on the lower level, in Exhibition and Prince Albert's roads; and the central pathway, upwards of 75 feet wide, ascending through terraces to the third great level, will lead to the winter garden. The whole garden will be surrounded by Italian arcades, each of the three levels having arcades of a different character. The upper or north arcade, where the boundary is semicircular in form, will be a modification of the arcades of the Villa Albani at Rome. The central arcade will be almost wholly of Milanese brickwork, interspersed with terra-cotta, majolica, &c., whilst the design for the south arcade has been adapted from the beautiful cloisters of St. John Lateran at Rome. None of these arcades will be less than 20 feet wide and 25 feet high, and they will give a promenade sheltered from all weathers more than three quarters of a mile in length. The arcades and earthworks will be executed by the Commissioners for the Exhibition of 1851, at a cost of £50,000, whilst the laying out of the gardens and construction of the conservatory or winter garden will be executed by the Horticultural Society, and will cost about the same sum, the greater part of which has been already raised.

The Wallace Monument.—The committee of the Wallace monument have awarded the first prize to a design by Mr. J. T. Rochead of Glasgow, which consists of a tower in the Scottish mediæval style, 220 feet high; and which it is understood will be at once erected. The second prize was awarded to Messrs. Peddie and Kinnear of Edinburgh; the third, to Messrs. Haig and Low of Glasgow.

New Long Range Cannon.—A long range cannon, invented by Mr. Jeffries, patentee of the well-known marine glue, is in course of being mounted in the Royal Arsenal, Woolwich, for experiments at Shoeburyness. The gun, with its present bore, namely, a 3-inch diameter, weighs 7 tons, and presents an appearance (with the exception of the present calibre) similar to one of our 68-pounders. The charge will consist of 16 lb. of powder, and a conically-shaped shot, weighted with lead to 9 lb., and hollowed similarly to the Minié bullet, which it is presumed will be propelled fifteen or twenty miles. Mr. Jeffries has asserted his conviction that it would carry from Dover to Calais. It is the intention of the authorities to carry out a varied and complicated course of experiments under the inspection of the Select Committee of Woolwich Arsenal. After being satisfied of its power in its present form, the bore will be progressively increased to a 68-pounder. To enable the gunners to point the gun, the trunnions will be fitted with a couple of telescopes, to assist the eye over the enormous range predicted.

Wroxeter Excavations.—The southern part of the ground in possession of the Excavations Committee is in course of exploration, and has already presented interesting discoveries. An undoubted street has been met with running eastwardly from the Watling-street-road, and, bounded apparently on the south by houses. This street appears also to form the southern limit of the great building containing so many hypocausts. Upwards of 200 feet of wall have been uncovered very recently, and in a short period a far better notion may be formed of the buildings hitherto laid bare. The excavations are now being carried on southward along the line of the main street (the modern Watling-street-road). Objects of rather a new character are met with in this part of the excavations, such as spears and javelins, pickaxes of curious form, and other implements. Among other objects is an elegantly formed lady's bracelet, of twisted brass, the two ends of which fasten with a small hook and eye. The great number of pieces of bone and horn found scattered about, which have been sawed and cut, and some of them partly turned in a lathe, is very remarkable, and seems to show that somewhere in the immediate neighbourhood of the present excavations there must have been a manufactory of objects made of such materials. Another reservoir for water, much deeper than the former, has been found at the southern part of the great building, and goes much towards confirming the conjecture that it was an establishment of public baths.

Digitized by Google

Photographs taken for Government Institutions.—To enable the public to derive full advantage from the photographic negatives made officially for the Science and Art Department, from rare and valuable objects in public and other collections, British and foreign, the Committee of Council on Education has caused an office for the sale of photographic impressions from such negatives to be established at the South Kensington Museum, which will be opened on the 3rd inst. Photographic negatives made by order of the trustees of the British Museum, and for the War and other government offices, will also be sold. The tariff for unmounted impressions will be as follows:—A single impression the dimensions of which contain less than 40 square inches—*e.g.* 5 inches by 7, or 4 inches by 8—5*d.* Above 40 square inches, 2½*d.* should be added for every 20 square inches or under. A detailed list of the objects photographed is printed, price 2*d.* The department does not charge itself with the mounting of impressions.

Traction Engine for the Egyptian Government.—One of the patent traction engines, or, as they are termed by the inventor, "steam horses," manufactured by Mr. Charles Burrell, of Thetford, in Norfolk, was a few days ago tested over the sandy and uneven thoroughfares leading to Plumastead-common, and was freighted with one of the 95 cwt. guns attached to a gun-carriage, together with a train of waggons, &c. It is intended to work economically on common roads and for agricultural purposes, or where no roads exist; and it is asserted that the engine and railway are capable of overcoming difficulties which no amount of horse-power can possibly accomplish. The engine left Woolwich on Wednesday under its own steam, and proceeded from the Royal Arsenal to the Nine-elms Railway station for conveyance, *viâ* Southampton, to Cairo. It was manufactured by order of Col. Tulloh and Mr. Anderson, of the War Department, at the request of the Egyptian government, and was supplied with its entire accessories—namely, the tender, capable of containing a supply of water and coals for a day's work, waggons, &c., together with a gun-carriage. The new engine is on the principle of Boydell's patent, as employed in Woolwich Arsenal, and is fitted with various alterations and additions, invented and patented by the manufacturer, such as an improved method of attaching the endless railway to the wheels by the instrument by which the rail is lifted passing through the wheel instead of at the side, so that the endless railway is balanced while being carried round on the wheel, by which means the friction and wear and tear are said to be considerably diminished. The patent wheels are also of a new construction, being composed of wrought-iron welded together, and are pronounced far superior to the wooden ones first introduced, and which in eastern climates are liable to be speedily destroyed by the red ants and other vermin. The rails and wearing parts are of steel, and the unwieldy appearance which the endless railway formerly gave to the engine, and which was the terror of horses and other animals on the road, is, under the present invention, ingeniously concealed by compact and light-looking covers. A second engine of a similar description is ordered to be constructed for India, at the request of the War Department.

Roman Remains.—A joint meeting of the Lincoln Diocesan and Northamptonshire Architectural Societies was held at Stamford on the 6th and 7th ult., to consider the progress made lately in architectural science, and to visit the architectural and antiquarian remains in the vicinity. The principal object of interest, however, was an excursion made to Apethorp-park, the seat of the Earl of Westmoreland, for the purpose of viewing the excavated portions of a Roman villa recently discovered there. A lecture was delivered by the Rev. E. Trollope on the subject, from which it appeared that the discovery of these remains, which from internal evidence seem to date from the fourth century, was the result of the merest accident. In the early part of the present year some workmen were employed in digging a drain in Apethorpe-park, when it was found that they were throwing out some Roman mortar. Further excavations being made, a hypocaust was bared, subsequently tesselated pavements, baths, various rooms, and a great extent of stone walls showing the "herring-bone" work. Walls extending about 120 yards from north to south have now been bared, and although sufficient progress has not yet been made with the excavations to show the general ground-plan of the building, the discoveries prove it to be the site of a Roman structure of very considerable extent. The labours of the workmen for some time after the discovery was made were directed in baring the hypocaust and adjacent chambers. The concrete floor over the former was destroyed, but all the pillars that supported it remained. These range in rows from east to west and north to south, there being five in that number of rows eastward to two thick pillars of the same height, and four in each of three rows on the flue side. The pillars, consisting of tiles cemented together, are eight inches square, the cap and base tile of each pillar being larger. The pillars are 16 inches high, and the same distance apart. The floor is of concrete, and when found was covered with black soot-like matter. The "herring-bone" stone wall near the flue is red from the effects of fire. The flue tile, quite perfect, was found here; it is 14 inches long, 7 wide, and 4 deep; it has a wavy ornament, probably made with a comb like instrument. On the east side of the hypocaust are the baths, and on the south and west sides are chambers, the floors of which are on a level with the floor of the hypocaust. On the north side is a portion of a tesselated pavement, the vari-coloured tesserae of the other parts having been disturbed by the root of a fine oak tree, said to be 170 years old. The two compartments or rooms westward of the flue are each 8 feet wide, and nearly square; the chamber on the south side of the hypocaust, from which it is divided by a wall 2 feet 4 inches thick, is rectangular. Eastward of the baths are other rooms which extend to the eastern wall. This portion of the exterior wall extends 70 feet, the south end terminating by a corner stone. The walls of several small rooms have been bared to this point. North of the baluem the eastern wall is more westward, extending 102 feet, and here also a number of chambers have been found; two circular cisterns, about 5 feet deep, have also been found, and as these are in the centre of the excavations it is believed they received the water that flowed from the compluvium. The two other tesselated pavements that have been found are more northward; one is 24 feet from east to west and 14 from north to south, and the other is 14 feet, nearly square; the last named is 20 inches below the surface, the colours of the tesserae being red and dark blue.

Tinned Lead Tubes.—The authorities of Paris have prohibited the employment of lead for tubes intended to convey beer or water for drinking purposes. M. Sébille, of Nantes, has invented an ingenious process for tinning lead tubes inside or out, or both, which from the specimens exhibited appears eminently successful, and which has the merit of cheapening the article, by reason of the superior resisting power of the tin permitting the diminution of the leaden tube by about one-tenth of the ordinary thickness of metal. Tinned lead tubes have been found to possess sufficient rigidity to allow of their being worked and bent without bulging inwards and flattening. Taking 500 metres of ordinary lead tubing, mixed guages, the weight will be 2460 kilos.; and at 70 francs the 10 kilos., the cost will be 1722 francs. Five hundred metres of the new tinned lead tubing, by reason of the reduction in the thickness of metal, will weigh 2214 kilos., which at 76 francs the hundred kilos. will make the cost 1682 francs, or 39 francs less for a less destructible and stronger article. The machinery and process of manufacture are as follows:—The molten lead is run by a side opening into a cast-iron vertical cylinder situated above the piston of an hydraulic press. The cylinder is closed at top by a cover having an opening of the diameter required, and in the centre of which is placed a mandril or core. The lead is allowed to solidify, that is to say, to fall to a temperature of from 482° to 518° Fah., at which it is kept by heat applied to the outside of the cylinder. When this temperature is reached, the hydraulic press is set working and the lead expelled through the annular opening in the cover; the mandril in the centre of the opening is provided on its circumference with four knives, which scrape the interior surfaces of the lead. On leaving the annular opening, the lead comes into contact with molten tin, which penetrates into its pores, and is firmly attached to its whole surface. As tin melts at 446° Fah., the lead possesses sufficient heat to keep the tin always fluid. A ring on the exterior or sphere in the interior of the tube, fixed where it leaves the machine, regulates the thickness of the tin coating and smoothes its surface. The reason, it may be remarked, of the tin attaching itself to the lead without the previous use of a mordant is, that the knives clean the surface which comes in contact with the tin before it can be acted upon by the atmosphere. The gas and water companies in the French towns use M. Sébille's tinned lead tubes to the exclusion of all others, on account of their economical and sanitary advantages.

Digitized by Google

Breech Loading Cannon.—The difficulty hitherto experienced in converting the ordinary cast-iron guns into breech-loaders has at length been surmounted by Mr. Warny, the inventor of the new breech-loading percussion cannon (which during some recent trials at Chatham discharged twenty shots per minute) who has just succeeded in attaching a wrought-iron breech to a cast-iron gun, the first attempt of the kind which has, as yet, proved successful. The gun experimented upon consisted of the ordinary cast-iron barrel, weighing about 40 lb., which having been rifled, Mr. Warny attached his breech-loading invention to it; this gun being also fired by percussion, as is the case with Mr. Warny's ordinary breech-loading cannon. The breech is provided with a lever fixed at the end, which by one movement lubricates the chamber, primes the nipple, and closes the breech. By an exceedingly simple contrivance the breech can be almost instantaneously detached from the other portion of the gun, so that in the case of a sudden surprise by an enemy, these guns can have their breeches removed and be rendered entirely unserviceable. During the trials made at Chatham on the 14th ult., to test the newly finished cannon, it was ascertained that with a small charge of gunpowder the shot could be thrown 4000 yards, or upwards of two miles, while by slightly increasing the charge a range of 5000 yards was obtained, the gun throwing a shower of balls at the rate of ten per minute; a rapidity of firing which the inventor is able to maintain as long as the ammunition lasts, the current of air admitted each time the breach is opened preventing the gun becoming heated and expanding. Mr Warny has expressed his readiness to take any ordinary metal or cast-iron gun now in use, and to convert it into a breech-loader which shall be capable of discharging from ten to twenty shots per minute a distance of at least three miles, the barrel being previously rifled.

The New Victoria Bell at the Leeds Town-hall.—The size of this bell, which has recently been cast, is 6 ft. 2 in., and 6 inches thick; and the weight is just 4 tons 1 cwt. It is made on the pattern of the latest in date of the Westminster bells. The Leeds and Westminster bells are thicker in proportion to their size than probably any other large bells, except the Russian ones. Bells are now sometimes made as thin as 1-16th of their diameter —of course, for the sake of economy, but with serious detriment to the quality of the tone. The Leeds bell was cast by Messrs. Warner by a new process, never before used; and the failure of most of the very large bells cast within the last two centuries proves that success is by no means an easy achievement. The fate of the first Big Ben of Westminster is recent enough to occur to every one. The great bell of Paris (Notre Dame), of nearly the same size, and nearly 13 tons weight, was cast three times over in as many years, under Louis XIV. St. Paul's bell, 5 tons 4 cwt. and 6 ft. 9 in. wide, was recast twice, by order of Sir Christopher Wren, and is still declared by musicians to sound no distinct note, but a double one, compounded of A and a third above. The bell of 7 tons, cast in London in 1843, for Montreal, was soon returned cracked, to be recast into a larger one, which has lately perished with the church by fire. Great Peter of York, though it cost £2000, and weighs nearly 11 tons, and is 8 ft. 4 in. wide, is a notorious failure, and is almost disused. Peter of Exeter is an inch wider than the Leeds bell, but also an inch thinner. The weight locally assigned to it, 5½ tons, is therefore evidently fabulous, and the clapper and clock hammer are so small that it is difficult to say what its true sound is. Great Tom of Oxford is pronounced by the learned, one of the worst bells in the world. He weighs 7 tons 12 cwt., and is 7 ft. in diameter. Tom of Lincoln, long the most famous bell in England, was killed on Christmas-day, 1807, and revived by Mr. Mears in 1835, on a rather larger scale, 4 cwt. heavier and an inch wider than St. Paul's. It is considered a good bell, but it is thinner for its size than Victoria, and of a different shape, and sounds rather feeble for a bell of that weight. These are the only bells in England exceeding this of Leeds in size, and we have reason to believe that not one of them, except, of course, Big Ben, with his 13½ tons, and hammer of 7½ cwt., will be equal to it in power or quality of tone when struck with a hammer of proper weight. Mr. Dent is making the clock, on the Westminster construction, which was approved by the Astronomer Royal, and from a new design made expressly for it by Mr. Denison, so as to be capable of raising a hammer of 2 cwt. a foot high. The bell is intended to be hung for ringing in full swing, and is made like the Westminster bells, and the Queen's clock bell at Balmoral, with a kind of mushroom top, to enable it to be turned in the stock when worn in one place.

Lincoln Cathedral.—The Dean and Chapter of Lincoln have resolved to devote £2000 to the repairs of their cathedral during the ensuing year. The north-east side of the sacred edifice is to receive attention. Last year £1300 was expended on the cathedral.

Submarine Boat.—We learn from the *Philadelphia Ledger* that on the 23rd August last, an experiment took place at New Castle, Delaware, with a submarine salvage boat, invented by Mr. Villeroi, who descends to the bottom of the river without any arrangement for receiving a supply of fresh air from above, the boat being intended to supply itself with the quantity of air needed while under water, enabling it to remain submerged for any length of time required. As singular as this may seem, the experiment yesterday showed that it was perfectly practicable, for eight men went down in the boat, and remained there an hour and three-quarters without any communication from above. The mode of generating air to supply the boat is yet a secret, but it is believed to be by some chemical arrangement. The boat is made of boiler iron, and is perfectly round, and shaped somewhat like a fish. It is 35 feet long, 44 inches in diameter, and propelled by a screw 3 feet in diameter. It has two rows of bull's eyes on the top, for the purpose of giving light to the interior. On each side, near the bow or head, are placed pieces of iron 18 inches square, which are moved like the fins of a fish, and are intended to direct the boat up or down when under the water.

Traction Engine for India.—A traction engine (Boydell's patent), ordered by the government of India for use in Bombay, was tested on the 14th ult. at East Acton, in the presence of several engineers and a gentleman sent down by the government to witness the experiment. The road selected for the trial was the bridle-lane leading from East Acton to Friar's-place, and, notwithstanding the heavy state of the ground caused by the rains, the expectations of the inventors were fully realised. Abrupt turns in the lane were passed without difficulty, and the engine, with a train of five waggons, measuring altogether 102 feet, was turned completely round in a space of 39 feet. The patent consists of "shoes" revolving with the locomotive wheels of the engine, forming an endless rail, thus saving the cutting up of roads, and at the same time facilitating progress. The engine exhibited was said to be capable of drawing fifty tons, and of moving with such a load on a gradient of one in six. The cost of working is comparatively small, the amount of fuel required being about one cwt. of coal per mile. The speed attained is from four to six miles an hour. This machinery was made for the government at a cost of £1200 for the engine, and £60 each for the waggons, which are supplied by Messrs. Croskill, of Beverley.

COMPETITIONS.

Designs and estimates are required for enclosing and laying out the new burial ground of Over Darwen, Lancashire, and erecting three chapels and entrance lodges. The designs to embrace a plan of the site, showing the position of the roads and walks, the land to be set apart for ornamental planting, the site of the chapels, the proposed division of the cemetery, and the drainage thereof; also plans, elevations, and sections (8 feet to an inch) of the chapels and lodges, with estimates. The site is 10 acres, and the total estimated cost about £4000. Two of the chapels must each have accommodation for 120 to 150 persons, and the third half that number. The architect whose plans shall be adopted will carry out the works at £5 per cent.: premiums of £20 and £10 will be given to the plans considered second and third in merit. The plans &c. must be sent to Mr. Thomas Clough, Clerk of the Burial Board, by the 17th instant.

The Corporation of Southampton are desirous of obtaining designs for the erection of a new building in the High-street, Southampton, to be called the Hartley Institution. The expense of the building not to exceed £8000. The author of the approved design will be employed as the architect to carry it out. Plans and sections to be to a scale of one inch to 10 feet, and elevations to a scale of one inch to 5 feet, finished with China ink or sepia only. Estimate of the cost of the building to be furnished. Competitors are requested to keep in view the scheme for the management of the institution. Copies of the scheme and a lithographed plan of the site, and all information, on application to Mr. Charles E. Deacon, Town Clerk, Southampton, to whom designs must be sent by the 1st December next.

Digitized by Google

Digitized by Google



NEW CHURCH, AT COWLEY.

G.E. Street, Archt 33 Montague Place, London.

Novr 1859

J.R.Johbins

Digitized by Google

NEW CHURCH AT COWLEY, NEAR OXFORD.

(With an Engraving.)

The church at Cowley, near Oxford, being inconveniently placed, very much out of repair, and much too small for the wants of the parish, it has been decided to build a new church in its stead, distant about half a mile from it. The new church will be built of Gibraltar and Bath stone, with marble shafts, the internal walls being all faced with stone. The eastern part of the chancel is to be groined. There will be accommodation for between 400 and 500 persons, in moveable open seats. The old church, which has some features of interest, will be repaired, and used for funerals and probably also for occasional services. The church is to be built from the designs of Mr. George Edmund Street, architect, London.

MR. ROBERT STEPHENSON.

Within a month—a little month—two of the greatest engineers of the present time have paid the debt of nature. In the last number of our Journal we recorded the death of Mr. Brunel, and now we have to lament the loss of his great rival in the profession, Mr. Robert Stephenson. Nearly of the same age, enjoying nearly similar advantages in their parentage and education, they pursued the same career, in the same field of action, and after having honourably distinguished themselves in achieving many bold and noble works for the benefit of mankind, both of them, worn out by their exertions and anxieties, have gone to the grave almost together, in the prime of their intellectual powers.

Though entering on their profession under circumstances generally so much alike, there were differences in their temperaments and in the qualities of their minds that made each take different views and pursue his operations under the guidance of almost opposite principles. It would be invidious now to attempt to compare the respective merits of these two great men, and posterity alone can decide which of them has done most to advance and which least to obstruct the progress of knowledge, and which has most contributed to improve the science of civil engineering, and done best service to society at large.

If success be taken as the standard of merit, no engineer who ever lived could equal Mr. Robert Stephenson. His whole life was a continued series of successes; and though he commenced in a more humble sphere than Mr. Brunel, the closer intimacy which that circumstance occasioned between him and his father was a most important advantage, for to the instruction derived from constant communication with a man of that pre-eminent genius much of his after success in life may be attributed.

The interesting memoir of Mr. George Stephenson, written by Mr. Smiles, gives much insight into the early life of his son. It is well known that Mr. G. Stephenson when a boy was occupied as a "trapper" in a coal pit. Nothing can well be conceived more horrible or more depressing to the mental faculties than weeks, months, and years spent in the dark passages of a coal mine, having nothing more to do but to open and shut from time to time the door he was placed to guard, to let the trams pass through. The force of his mechanical genius rescued him from that dismal dungeon, and by mending the watches of the pitmen, by making or repairing their clothes, by shoemaking and other means, he contrived to add to his wages. As Mr. Smiles informs us, he thought himself a happy man when, in 1802, on earnings of £1 a week, he could offer his hand and fortune to the pretty farm servant, Fanny Henderson. After the marriage he took home his bride behind him on a pillion—their bridal attendants, Sister Anne and Robin Gray, accompanying them, similarly mounted, to Willington. The Hendersons and Stephensons, though poor enough, were of a good stock; and as Fanny had married George, the rising breaksman of the quay, so Anne Henderson married her master Farmer Burn, who had lent the horses for the wedding procession; and Betty Henderson, a third sister, became the wife of Farmer Paterson, of Black Callerton, with whom George was a lodger in his bachelor days. His home then was at Willington-quay, on the north bank of the Tyne, about six miles below Newcastle. His biographer tells us that his signature, as it appears in the parish books on the occasion of his marriage, was that of a person who had just learnt to write.

"It was while living at Willington-quay that George Stephenson's only son Robert was born on the 16th of October 1803. The child was from his earliest years familiarised with the steady industry of his parents, for there were few if any idle moments spent in that cottage. When his father was not busy in making or mending shoes, cutting out shoe lasts, or cleaning clocks, he was occupied with some drawing or model, in constructing which he sought to improve himself. The child was from the first, as may be well imagined, a great favourite with his father, whose evening hours were made happier by his presence."

In 1804 the elder Stephenson removed to West Moor, Killingworth, taking with him his little son. His loving wife, the interesting and pretty Fanny Henderson, was not long to be a sharer of his improving fortunes. She finished her course shortly after removing to their new dwelling. Whilst at Killingworth the world smiled on George Stephenson. He became engineer of the colliery, he attracted attention by his invention of the safety-lamp, and he developed the germ of the railway system. "Little Robert," as he was called long after he had passed the season of childhood, was not an uninterested spectator of these things. A picture of the above-ground workings of the pit in the dark passages of which George Stephenson risked his life on the soundness of the principle of his safety-lamp, adorns the walls of the house which Mr. Stephenson occupied in Gloucester-square. The silver tankard which was given to the elder Stephenson, along with a thousand guineas, by the owners of Killingworth Colliery and other admirers of his genius, was ever prized by his departed son as among the most precious of his possessions. It used to stand in the centre of his side-board raised upon an ebony support.

The first part of Robert Stephenson's education was received at the village school of Long Benton, of which the parish clerk, Mr. Cutter, was master. At length the time arrived when his father's aspirations were to be realised, and his son was to be placed within the influence of higher educational advantages than belonged to the station of life in which Mr. Stephenson then moved. At Midsummer 1815, Robert became a pupil in Mr. Bruce's academy in Newcastle. "At this time" observes the *Northern Daily Express*, from which we have gleaned several of the following particulars, "he was a rough unpolished country lad. His dialect was that of the pit districts. He was always a sprightly fellow, fond of fun, and, like most of his family, delighted in practical jokes. The last time he visited Killingworth he was reminded of his youthful disposition. He encountered a man of the name of Clark, who now keeps a crossing upon the railway. Clark, on being told who he was, and asked if he remembered him, by way of proving his claim to the distinction of ancient acquaintanceship, said, with much emotion, 'Haven't I paid your head many a time when you came with your father's bait (food), for you were a hempy (mischievous) boy.' He was often teased by his schoolfellows, in order to draw from him some rough Doric expression of his sense of the annoyance. However, he is chiefly remembered by them for his kindliness of disposition and his application to his studies. At this time he formed friendships which his death alone severed. Foremost in the school at Percy-street at this time was Mr. John Taylor, the auditor of the Carlisle Railway Company: Mr. Bruce always regarded him as a model boy, and held him up to the laggards as an example of good conduct and industry. Stephenson, speaking of him in after days, used to say, 'John Taylor could beat me at arithmetic,' but he usually added with much animation, 'I could beat him at mensuration.' As the distance between Killingworth and Newcastle was too great to be daily traversed on foot, he used to ride into town mounted upon a cuddy. Little did he dream, as he scampered on his ass along the black and blashy lanes of Gosforth and Long Benton, of a journey performed in a saloon carriage upon a railway, at the rate of sixty miles an hour; and yet all the while he was preparing for the accomplishment of this feat."

Stephenson left school well grounded in the principles of his own language, and with some knowledge of French; conversant with geography and astronomy, and an adept at arithmetic, geometry, and algebra. Mr. Bruce lived to see his pupil enter upon his brilliant career, though he died before the completion of his first great work, the London and Birmingham Railway. The attachment between pupil and teacher was very great. Mr. Bruce watched his course with pride and satisfaction, and Mr. Stephenson, with that humility which was so characteristic of him, used to tell his old master that he owed, in a great measure, his position in society to his instruction. Nor did he confine his expressions of gratitude to words.

Digitized by Google

On leaving school, at the age of fifteen, Robert Stephenson was apprenticed to Mr. Nicholas Wood, at Killingworth, to learn the business of the colliery, where he served for three years, and became familiar with all the departments of underground work. When his duties in the pit and in the office were over, he prosecuted at home with diligence his favourite mathematical pursuits. He was not satisfied with acquiring knowledge himself—he sedulously instructed such of the young men around him as were disposed to learn. His father, shortly after he left school, desired him to construct a dial for the front of his cottage, adapted to the latitude of the spot. Robert had not learnt that particular application of the mathematical principles with which he was familiar, and remonstrated. But remonstrance was of no use. George Stephenson knew nothing of impossibilities, and he saw no reason why other people should. The son accordingly set to work, and at length achieved the task, though at the cost of many a headache. The dial still remains. On the occasion of a recent visit to Killingworth, Mr. Stephenson pointed out to the friends who accompanied him the little room in which he prosecuted his inquiries, and the desk at which he sat. To the great astonishment of the present occupant of the cottage he pointed out a secret drawer in the desk which she had not discovered. Touching a spring, the drawer flew open—unfortunately it was empty.

When Robert Stephenson was serving in the capacity of underviewer in the West Moor pit, an accident occurred that might have terminated fatally. He was accompanying Mr. Wood, the head-viewer, through the pit, when Wood imprudently held a naked candle to examine an opening where the roof had fallen in. An explosion of fire-damp was the immediate consequence. They were blown down, and the lights extinguished, but with the exception of some bruises they escaped uninjured. George Stephenson's safety-lamp had been for some time in use in the pits, and the men were forbidden to go into the mine without it, but it happened then, as now with the Davy lamp, such injunctions were but partially obeyed. His father was engaged at the same colliery, and the evenings of both were usually devoted to their mutual improvement. Mr. Smiles describes the animated discussions which in this way took place in their humble cottage.

"The youth was entered a member of the Newcastle Literary and Philosophical Institution, the subscription to which was £3 3s. a year. He spent much of his leisure time there reading and studying, and on Saturday afternoons, when he went home to his father's at Killingworth, he usually carried with him a volume of the 'Repertory of Arts and Sciences' or of the 'Edinburgh Encyclopædia,' which furnished abundant subjects for interesting and instructive converse during the evening hours. But many of the most valuable works belonging to the Newcastle Library were not permitted to be removed from the room; these Robert was instructed to read and study, and bring away with him descriptions and sketches for his father's information. His father also practised him in reading of plans and drawings without at all referring to the written descriptions. He used to observe to his son: 'A good drawing or plan should always explain itself;' and placing a drawing of an engine or machine before the youth, he would say, 'There, now, describe that to me—the arrangement and the action.' Thus he taught him to read a drawing as easily as he would read a page of a book. This practice soon gave to both the greatest facility in apprehending the details of the most difficult and complicated mechanical drawing. The son, like the father, was very fond of reducing his scientific reading to practice. On one occasion, after reading Franklin's description of the lightning experiment, he expended all his hoarded Saturday's pennies in purchasing about half a mile of copper wire at a brazier's shop in Newcastle. After previously preparing his kite, he sent it up at the cottage door, insulating the wire by means of a few feet of silk cord. His father's pony was standing near, waiting for the master to mount. Bringing the end of the wire just over the pony's crupper, so severe an electric shock was given it, that the brute was almost knocked down. At this juncture the father issued from the door, with riding-whip in hand, and was witness to the scientific trick just played off upon his galloway. 'Ah! you mischievous scoundrel!' cried he to the boy, who ran off. But he inwardly chuckled with pride, nevertheless, at his son's successful experiment.

"The connection of Robert with the Philosophical and Literary Society of Newcastle brought him into communication with the Rev. William Turner, one of the secretaries of the institution. That gentleman was always ready to assist the inquirer after knowledge, and took an early interest in the studious youth from Killingworth, with whose father also he soon became acquainted. Mr. Turner cheerfully and even zealously helped them in their joint inquiries, and excited while he endeavoured to satisfy their eager thirst for scientific information."

The evening discussions between George Stephenson and his son frequently turned on the then unknown powers of the locomotive engine. The son was even more enthusiastic than the father on the subject. Robert would suggest alterations and improvements in all the details of the machine. The father would make every possible objection, defending the existing arrangements, but proud, nevertheless, of his son's suggestions, often warmed by his brilliant anticipations of the triumph of the locomotive, and perhaps anxious to pump him as much as he could. It was probably out of these discussions that there arose in George Stephenson's mind the desire to give his son a still better education. He sent him in the year 1820 to the Edinburgh University, where Hope was lecturing on chemistry, Sir John Leslie on natural philosophy, and Jameson on natural history. Great were the advantages which he derived from their teaching. Sir John Leslie was blamed by the majority of his pupils for the profundity of his mathematical disquisitions; in these Stephenson delighted. Jameson had enjoyed the personal instructions of the great Werner, and had by his own eminence and zeal given a powerful impulse to the study of geology and mineralogy in the northern metropolis. Mr. Stephenson, at the close of each day, made a practice of writing out in full a report of the lectures he had heard at the classes. This was a work which sorely tasked his perseverance. He afterwards had these reports carefully bound up, and the volumes occupied a conspicuous place in his library. Often in conversation with friends upon scientific subjects he referred to them, instead of consulting printed books. It was the custom of Prof. Jameson, at the close of the session, to select a party of his most successful pupils to accompany him in an excursion over some of the most interesting parts of Scotland. Mr. Stephenson was one of the chosen band of his year. Only a few months ago, when under the shadow of Ben Nevis, he expatiated to a friend upon the benefits that he derived from this expedition, in which, as he said, the professor, instead of illustrating his positions by chalk diagrams upon a black board, referred his pupils to the teachings of the great Creator, as expounded by his own handiworks. Though young Stephenson remained in Edinburgh but six months it is supposed that he did as much work in that time as most students do in a three years' course. It cost his father £80, but the money was not grudged when the son returned to Killingworth in the summer of 1821, bringing with him the prize for mathematics, which he had gained at the University.

In 1822 Robert Stephenson was apprenticed to his father, who had by this time started his locomotive manufactory at Newcastle; but his health giving way after a couple of years' exertion, he accepted a commission to examine the gold and silver mines of South America. With no small degree of trepidation he presented himself, accompanied by his father, before Dr. Headlam of Newcastle, to ascertain whether he might venture upon the expedition. During the examination which ensued he felt as if he were upon trial for life or death. The doctor, to his great relief, pronounced an opinion that a temporary residence in a warm climate was the very thing he wanted. He accordingly set sail, and the moment he landed upon the shore of his destination all his ailments left him. He had occasionally to sleep for nights together in the forests, and not unfrequently exposed to incessant rain; all this he endured, not only without detriment, but with advantage to his constitution. Mr. Stephenson's residence abroad was of great importance to him. Not only did he profit by a change of scenes and habits and manners, but by the class of persons with whom he was thrown in contact. After having founded the Silver Mining Company of Columbia, he returned to England in December 1827. "On his way home," says Mr. Smiles, "Mr. Stephenson had a singular rencontre with a person well known in connection with the early history of the locomotive. He was waiting for a ship in which to embark for New York at the small town of Cartagena, in the gulph of Darien. No vessel being ready to sail, he was under the necessity of staying for some days in the place, then desolated by the ravages of the yellow fever. Sitting one day in the large, bare, comfortless room of the miserable hotel of the almost deserted town, he observed two strangers whom he at once perceived to be English. One of the strangers was a tall gaunt man, with shrunken

Digitized by Google

flesh on which his shabby clothes hung loosely. On making inquiry he found it was Trevithick! He was on his way from the gold mines of Peru, and was penniless! Still he was full of speculation, and was returning to England, where he proposed to organise a gold-mining company that was to make the fortunes of thousands. Trevithick and his friend had lost everything in their journey across the country from Peru. They had forded rivers and wandered through forests, leaving all their baggage behind them, and had reached thus far with only the clothes upon their backs." Trevithick's career in Peru had been magnificent while it lasted; he had been received with acclamations and public honours; and the manager of the mining speculation declared that "Heaven had sent them Don Ricardo Trevithick for the prosperity of the mines." His friends at home represented that his emoluments, taken at a moderate estimate, amounted to £100,000 a year. Stephenson was consequently greatly astonished to behold Don Ricardo in such a woeful plight, and lent him £50 to bring him back to England.

On coming home, Robert Stephenson found his father largely embarked in the engine works at the Forth Banks, Newcastle. The elder Stephenson was beginning to find that something more than mechanical genius was requisite in order profitably to conduct a large commercial speculation. Robert soon unravelled the accounts, exposed the deficiency which was yearly accumulating, and, diving to the root of the mischief, put the affairs of the factory into a healthy condition. At this time, too, the railway system was struggling into life. The elder Stephenson was capable of achieving any mechanical feat which the mere impulse of genius could effect, but without the means and appliances which science affords, and with which his son was amply provided, he could not so speedily, if at all, have routed the enemies of the locomotive, and perfected that system of travelling which bids fair to revolutionise the habits and modes of thought of the whole world.

The formation of the Liverpool and Manchester Railway was the culminating point in George Stephenson's career, and the success of his locomotive engine the Rocket, which bore away the prize of £500, and greatly exceeded all the stipulated conditions by its performances, completely settled the question whether the railways should be worked with stationary engines or with locomotives. There is no doubt that Robert Stephenson, who was at the head of his father's factory at that time, greatly contributed to its success by his advice and assistance.

The first great work on which Mr. Robert Stephenson was engaged independently of his father, was the London and Birmingham Railway. The first sod of that railway was cut at Chalk Farm, June 1st, 1834, and the line was opened September 15th, 1838. During these four years, and while superintending the line, he walked over the whole distance from London to Birmingham more than twenty times, an example of conscientious and thorough superintendence, which others would do well to imitate. During the execution of the work, Mr. R. Stephenson took a house on Haverstock-hill, Hampstead, to be near that end of the line, where the tunnels under Primrose-hill and at Kilsby were the subjects of great anxiety. One contractor, who had contracted for the Kilsby tunnel, died of fright at the responsibility which he had assumed. It was ascertained that about 200 yards from the south end of the tunnel there existed, overlaid by a bed of clay 40 feet thick, a hidden quicksand. The danger was so imminent that it was seriously proposed to abandon the tunnel altogether, but Robert Stephenson accepted the responsibility of proceeding, and in the end conquered every difficulty.

All that time he had not ceased to devote his attention to the manufactory in Newcastle, convinced that good locomotives are the first step to rapid transit; and his assistance was sought by many companies, anxious to secure his advice if not more constant service. His evidence before parliamentary committees was grasped at, and it may be said that in one way or another he has been engaged on all the railways in England, while in conjunction with his father he has directed the execution of more than a third of the various lines in the country. Father and son were consulted as to the Belgian system of railways, and obtained from King Leopold the Cross of the Legion of Honour in 1844. For similar services performed in Norway, which he visited in 1846, Robert Stephenson received the Grand Cross of St. Olof. So also he assisted either in actually making or in laying out the systems of lines in Switzerland, in Germany, in Denmark, in Tuscany, in Canada, in Egypt, and in India.

It was in overcoming the difficulties of the great Kilsby tunnel, and in the bridges which he erected for railway purposes, that his genius as an engineer was most strikingly displayed, and by these it is that he will be best remembered. Of his bridges the most important are the high-level one at Newcastle, constructed of wood and iron; the Victoria-bridge at Berwick, built of stone and brick; the bridge in wrought and cast iron across the Nile; the Britannia-bridge over the Menai Straits, and the great Victoria-bridge over the St. Lawrence. A full account of most of these works is given in an article on iron bridges contributed by Mr. Stephenson himself to the 'Encyclopædia Britannica'. They are all splendid works, and have made his name famous over the world. The idea of the tubular bridge was an entire novelty, and as carried out at the Menai Straits was a grand achievement. With the assistance of Professors Hodgkinson and Fairbairn, in experiments on the best forms of the various portions of the structure, the difficulties were triumphantly overcome, and in less than four years the bridge was opened to the public, on March 18, 1850. It was the first thing of the kind ever attempted, and the success was so triumphant that under Mr. Stephenson's auspices it has been repeated more than once. In the Egyptian railway there are two tubular bridges, one over the Damietta branch of the Nile, and the other over the large canal near Besket-al-Saba; but they have this peculiarity, that the trains run, not as at the Menai Straits, within the tube, but on the outside upon the top. It is with this method of tubular bridging that Stephenson's name is peculiarly identified, and by which he will probably be best known to posterity as distinguished from his father, who has almost the entire credit of the railway system. One great feature of all Mr. Stephenson's works was his caution. He eschewed all rash enterprises. He valued security above dash. The importance of this at the commencement of the railway movement cannot be over-estimated.

In addition to his railway labours, Mr. Stephenson took a general interest in public affairs and in scientific investigations. In 1847 he was returned as member of parliament, in the conservative interest, for Whitby in Yorkshire, for which place he continued to sit until his death. He most liberally placed at the disposal of Mr. Piazzi Smyth, his yacht and crew, to facilitate the interesting meteorological investigations undertaken by that gentleman at the Island of Teneriffe. He was president of the Meteorological Society; an honorary but active member of the London Sanitary and Sewerage Commissions; a Fellow of the Royal Society; a member of the Institution of Civil Engineers since 1830, of which institution he was member of council during the years 1845 to 1847, vice-president during those from 1848 to 1855, and president during the years 1856 and 1857. In the latter year he received the honorary degree of D.C.L. from the University of Oxford, amidst the enthusiastic applause of the students. He received a great Gold Medal of honour from the French Exposition d'Industrie of 1855, and is said to have declined an offer of knighthood from Her Majesty. He is also the author of a work 'On the Locomotive Steam-Engine,' and another 'On the Atmospheric Railway System.'

There is no doubt that Mr. Stephenson's life was greatly shortened by the severity of his mental labours. His anxiety as to the success of the Conway and Menai bridges deprived him of any refreshing sleep for a considerable period. His nervous system became unstrung; his heart sympathised with the brain, and eventually his liver was implicated. The wonder is not that he has at length fallen, but that he lived so long. The disastrous launch of the Great Eastern seems to have contributed to the final catastrophe. Eager to assist Mr. Brunel, he came to his aid. When superintending some operation he came to the end of a balk of timber without knowing it, and fell up to his middle in the slime and water of the Thames. He refused to retire until the work on which he was engaged was completed. The consequence was an inflammation of the lungs, which confined him to bed for a fortnight. When he sailed for Norway in his yacht, soon after the close of the session, he was in indifferent health, and during his stay there he was attacked with a complaint of the liver. He returned to England, and on the voyage the yacht encountered severe weather, causing him to suffer from sea sickness for the first time. An attack of jaundice ensued, and on landing at Lowestoft it was necessary to carry him to the railway carriage. Upon his arrival in London it was found that he was in danger. Dropsy set in, and he was too weak to admit of its being relieved. Congestion of the liver also took place, but the former disease was the immediate cause of his death. He died

Digitized by Google

comparatively free from pain. During his illness he was unceasingly attended by the most eminent men in London. His cousin, Mr. Stephenson, and Mr. Bidder, were constantly with him throughout his illness.

Mr. Stephenson shone in private life. He was of a most kind and sociable disposition. Nothing could be more beautiful than his conduct as a son, unless it were the tenderness of his father towards himself. There was no presumption on his part, no jealousy on his father's. The two worked together as one man, each being only jealous of the other's honour.

Mr. Stephenson married in the year 1829 Frances, daughter of John Sanderson, Esq., of London, who died without issue in 1842. From that time to his death Mr. Stephenson remained a widower, residing chiefly at his house in Great George-street, Westminster, the idol of his domestics, many of whom have grown grey in his service.

His integrity was most remarkable. "During the height of the railway *furore*," observes the *Northern Daily Express*, "when the struggles of the various competing lines before parliamentary committees were conducted with a fierceness greatly in excess of the occasion, many railway men yielded to the claims of party rather than of truth. It was not so with Robert Stephenson. It was often remarked of him that he did not prove so ready a witness as many of his rivals. The truth was, he had to think before he could answer; and he had to frame his answer according to the dictates of judgment and conscience, not the interests of his company. The confidence which all parties reposed in him prevented much heartburning and litigation. When the London and Birmingham Railway was contracted for, both engineers and contractors had their experience of large works to acquire. The consequence was that many of the contracts were taken at an undervalue. Mr. Stephenson in such cases always stood between the contractor and undeserved ruin. Of late years, Mr. Stephenson has been most extensively appealed to as a healer of differences from all parts of the kingdom. His decision was universally considered to carry with it the two great elements which render an adjudication valuable: the highest amount of knowledge, and the strictest impartiality. He bowed to no man, but he bowed to justice. It was this unbending integrity which led him to acknowledge merit wherever he found it. Some men are so wrapped up in self, that they cannot see good in any other man. Mr. Stephenson was not one of these. No one had so modest a view of himself as he. The incense of flattery, which some inhale with so much greediness, was hateful to him. He was eager to give to every man the credit that was due to him. The consequence was that he was always surrounded by a band of rising engineers, who delighted to serve him. With so able and so generous a chief, and so devoted a staff, no wonder that such marvels were achieved. Others might envy him; he envied no man. The utmost sociability existed between him and the engineering body. He was seldom denominated by the stiff and formal phrase, 'Mr. Stephenson;'—'Robert,' or 'The Chief,' were the familiar terms by which he was generally known. Mr. Stephenson was a man of unbounded liberality. When a service had been rendered to him he knew no stint in the returns which he made. Money had no charms in his eyes; the truth is, he had no time to make use of it. Often, when his services have received from the directors of a railway more than the anticipated reward, has he distributed the overplus amongst his subordinates. One special instance of his liberality the inhabitants of this district (Newcastle) will not readily forget. Having in his youth derived great benefits from the stores of mathematical and scientific learning which the library of the Literary and Philosophical Society contains, he resolved upon putting these advantages, if possible, within the reach of every mechanic. One half of the debt upon that institution, amounting in all to £6200, he paid, in order that the subscription fee might be reduced to its original amount, one guinea." As a further proof of Mr. Stephenson's benevolence, it may be mentioned that he dispensed annually in charity several thousand pounds, in the most unostentatious manner.

On the 21st ult. the mortal remains of him whose loss we deplore, were deposited in the presence of thousands of mourners with becoming solemnity in the vaults of Westminster Abbey, side by side with those of Telford. The two great works that will immortalise them are close together, and it is fitting that their bodies lie together in the tomb.

The following grateful tribute to the memory of Robert Stephenson in the *Journal of Gas Lighting*, written by a member of the profession, notices an important fact, and points a warning that deserves the earnest attention of civil engineers:

"The most important lesson to be derived from the deaths of Stephenson and Brunel, or equally from those of Rendel and Alexander Wright, appears to be that the active, energetic pursuit of a profession like that of Civil Engineering, as it has become of late years, is highly destructive of human life. All the men we have named were men naturally of strong constitutions, and the amount of mental and physical labour they went through must have been fearful. The consequence was that none of them attained the age of fifty-seven, and they fell victims, ultimately, to attacks of disease which they would, no doubt, have shaken off easily when in their natural state of health. It really would seem that engineers, to use a vulgar phrase 'burn their candles at both ends' when they are men of genius, and in serious earnest in the pursuit of their profession. We suspect that this is not a properly-balanced frame of mind, and that there is something wrong in the immoderate pursuit of fame and fortune which it indicates. Yet who can say that this was the case, when Stephenson found time, and seized every opportunity, for rendering himself so beloved, that he was followed to the grave by such troops of sorrowing friends as to render his funeral almost equivalent to a national testimony to his worth? What a life that must have been which inspired such regrets! Gentle and simple, high and low, were present on the occasion; and legislators were mingled with hard-handed, noble-hearted mechanics to render homage to the man who had proved himself to have been not only the ablest, but one of the kindliest and most generous characters of his age! The bitterness of death would be soothed to Stephenson's surviving friends by a nation's grief for their bereavement. Let us strive to appropriate to ourselves the merits and virtues of the deceased, that when we too are gathered to the dust to which all must return, we may leave behind us as endeared and as enduring a memory as Robert Stephenson has done. Perhaps, also, we should do wisely to follow with less exclusive devotion, than either of the great men we have referred to seem to have done, the pursuit by which our worldly position is to be secured. They themselves might have enjoyed a longer career of usefulness, and rendered service to society for a longer period, had they been content to measure the expenditure of their faculties and of their strength."

LECTURES ON ARCHITECTURE AT THE LONDON UNIVERSITY.

On the 18th ult. Prof. Donaldson commenced his periodical course of lectures at the London University. The learned professor's introductory lecture was on the Christian Basilica. Of this we have the pleasure of printing an abstract, and propose subsequently to give our readers a general report of the course as the lectures are delivered.

On the Christian Basilica.

There is such a great variety of opinions in the various writers who have treated on this subject respecting the origin of the Christian basilica, that it is difficult to reconcile their jarring ideas on the origin of this peculiar feature of early Christian architecture. Quatremere de Quincy, differing from Uggeri de Caumont and many older writers, considers it impossible that the basilicas of the ancients should have been adopted as the churches of the early Christians; still it is difficult altogether to reject the *tradition* of the name, and if the Christian church itself had not been a basilica of the pagans, there can hardly be a doubt that the convenience of the arrangement of the latter suggested a form adapted to the wants of the followers of the new religion. It is not to be supposed that the early Christians, who had been accustomed to celebrate the rites and ceremonies of their faith in quarries, catacombs, or caverns, could have appropriated to themselves the most sumptuous of the public buildings of the ancients, or have celebrated their worship in anything like the sacred basilicas of Rome, until the fostering protection of Constantine the Great gave them encouragement, and by the construction of the basilica of St. Peter's afforded a becoming temple to the Christian world.

It is evident that the hatred of the first Christians for anything connected with pagan worship should disincline them to adopt the

Digitized by Google

form of the early temple of the heathen idolater. Besides which, the temples of the ancients were not calculated for the congregation of numerous worshippers: within the temple the lesser sacrifices alone were offered, and the priest and a few others only were inside, the great sacrifices being generally outside, and the people congregated on the exterior. But the Christian worship being probably of longer duration, a great part occupied in prayer and congregational worship, it was necessary to provide spacious covered places, where the people could be less exposed to heat and rain, and able also to sit down.

The arrangement for the worship of the new faith naturally suggested the adoption of the basilica, or court of justice of the ancients, as offering a great extent of accommodation for the people, combined with simplicity of plan and construction.

Constantine, in 324 A.D., was the first to construct a Christian basilica worthy the new religion to which he had been converted. He chose the site of the circus of Caligula, one side of which he made use of as the foundation for the walls and columns of one side. It is said that the zealous neophite bore on his imperial shoulders twelve basketfuls of earth, in honour of the twelve apostles, to fill up a portion that required additional elevation of soil.

We will now proceed to the consideration of the general arrangement of the plan. The basilica being raised above the general level of the valley, there was in front a flight of steps leading up to a level platform, where the popes were accustomed to come out and meet the emperors who were about to enter the temple for the purpose of worship, or to be annointed and crowned, as sometimes took place in this cathedral. Here also was a loggia or balcony, where the pontiffs gave the benediction to the assembled multitude.

Three gates afforded access to the fore-court; on one side was a lofty tower, with steps leading up to apartments in a gallery above for the residence of the inferior clergy. The central hall in some instances served as a baptistery, emblematic of that rite being the sacred ceremonial by which access was gained into the church.

The forecourt was spacious, surrounded on all its sides by a colonnade, and containing within its area various altars and sacred appendages,—next the west end was the porch, beyond which the penitents for more grievous sins were forbidden to go, until they had by this penance wiped off somewhat of the heinousness of their transgressions. A second door led into the body of the church, which consisted of a nave and two aisles on each side, forming thus five avenues divided by ranges of columns, the central one being wider than the two wall ones added together. The part near the doors, called the narthex, was appropriated to the penitents for more venial offences or catechumens, where they partook of the holy offices until being quite purged from their sins, or the neophites better versed in the doctrines and mysteries of the faith, they were allowed once more to join the great congregation of the faithful. Here also were the basins for the holy water with which the people were accustomed to sprinkle themselves immediately on entering the church, a superstitious usage emblematic of their being washed from their worldly sins immediately they entered the holy fane. In the earlier times the aisles on the right side were appropriated to the men, those on the left to the women. The church in this part was 270 palms wide, and 385 long up to the transept. Here a wall divided the nave and aisles from the upper end of the church, narrower openings led from the aisles into this part, but a wider aperture united the nave with the transept. In the smaller basilica a portion of the nave was appropriated to the priests, and therefore called presbiterium, near which was the ambon or pulpit for reading the gospel; this was frequently of marble enriched with mosaics, and inclosed by a marble parapet or ballustrade; and on the other side was a corresponding ambon for the epistle, a practice borrowed from the Greek church, but since discontinued in the Latin or Roman Catholic church. It will be perceived that the end of the church is formed by a semicircular niche called an absis, a distinguishing feature in the older churches. The throne of the pope or bishop occupied the bottom of the absis or tribune, and to the right and left are the seats of the choir or cardinals: this part is called the sanctum sanctorum or sanctuary, from the sacredness of its destination, and is inclosed by twelve columns to give it greater dignity. We recognise this part as corresponding with the chalcidicum in the heathen basilica, where the emperor, consul, or prætor, assisted by the assessors, sat as judges to hear causes. There was a large open space so as to allow of sufficient room for the numerous persons who attended to hear and take part in the causes.

In the basilicas of the ancients there was an order of columns over the columns of the nave, but in the Christian church there was a lofty wall divided into several heights by rows of pilasters, the spaces between which were filled in with panels and paintings of subjects taken from the Scriptures, the portraits of popes, and other appropriate subjects, and there were also windows which admitted light into the body of the nave. Sometimes there was a straight architrave from column to column under the clerestory, as at St. Maria Maggiore; at others there were arches over the columns. Sometimes the columns which divided the side aisles were of less size than those of the nave, and there was a sloping roof from the side wall of the aisle, which abutted against the clerestory wall and contributed to keep it steady, acting as an abutment, as at St. Paul's outside the Walls. We thus see that the form and disposition of these basilicæ were most judicious and advantageous. When the ordinary offices were performing, and only few were present, the people occupied the transept, but on the occasion of grest festivals and solemn pomps, the vastness of the nave and aisles afforded space for the largest multitudes, the view was but slightly impeded by the columns, and the lofty clerestory afforded ample ventilation for the assembled throng. Again there was a great economy in the construction, and of their solidity the best proof is their duration for above twelve or fifteen centuries. The flat roof of the nave had also an imposing effect, of which those may form a very competent opinion who have been to St. Alban's Abbey, the flat ceiling of which has a stern and impressive character. The only decoration of the interior was the columns, and paintings on the flat walls above, but the various altars scattered throughout, some attached to the walls, others in the central area near the columns, the tombs of the popes, the sacred relics of other buildings, the numerous statues in marble and bronze, the votive offerings of pious gratitude profusely scattered around, and other objects of curiosity or veneration, gave a rich and varied aspect to the edifice, and made the worshipper feel that he was on holy ground and in the immediate presence of his Maker and Redeemer.

The basilica of St. Clement, built in the ninth century (according to M. de Caumont), presents a simple arrangement of plan, combining all the essential parts of a basilica, and retaining all the old traditions of the primitive ages. It has a forecourt like the old basilica of St. Peter's. But in many early Christian churches there is no forecourt, only a portico in front. St. Clement's was evidently a pagan temple converted into a Christian church, of which there are many instances in Italy. A row of columns, some of them since encased in a wall, divides the nave from the side aisles. The ambones here are most marked, and form a very handsome arrangement, being of marble. The high altar, as was usual in some cases, is raised above the level of the nave, sometimes elevated very many feet: and beneath is a crypt called a confession, where were usually deposited the remains of the saint. To this there was an access by a flight of steps, tapers kept burning therein, and an officiating priest in some instances constantly praying or saying masses. This elevation of the altar produced a fine effect. The central absis is arranged, as in old St. Peter's, but on each side at the end of the side aisle are smaller absides, of which there are frequent examples. In these examples there is no transept, and indeed we do not find a transept an essential feature in the earlier Christian churches: the expansion adopted at first for convenience, became in the later times of more confirmed superstition emblematic of the cross, and considered an indispensable arrangement.

IMPROVEMENTS IN THE STRAND.

On a portion of the Craven estate which is situated at the western end of the Strand, abutting against Northumberland-house, improvements have just commenced on a somewhat extensive scale. These improvements are to be effected by the clearing away of the old shops and houses extending from Northumberland-house to Hungerford-street; the first block comprising the south-eastern corner of Craven-street, and the second including a great portion of the range of buildings in the Strand reaching to Hungerford-street.

In the street improvements of London we have on former occasions urged the necessity of appointing some responsible architect to have control over the external designing of all

Digitized by Google

new street buildings, in order to effect some degree of uniformity of architectural display, and now again urge the necessity of some such step being taken by government. In several instances, particularly in the city, all attempts at architectural harmony seems to have been completely abandoned in the new structures that have been erected within the last five years,—one house being carried up four or five stories in height faced with brick; another in stone three stories high, whilst a third adjoins rejoicing in black compo or Portland cement dressings washed over with stone colour.

In the case before us a fine opportunity which should be taken advantage of, is afforded for erecting a range of good street buildings in a line with the principal façade of Northumberland-house. These new buildings should be faced with red brick with stone dressings, and be designed so as to harmonise with that structure, without however adopting so much ornate embellishment in moulded work and carved ornaments.

ON THE PRINCIPLES AND PRACTICE OF CIVIL ENGINEERING.

A Course of Lectures delivered at the Royal Engineer Establishment for Field Instruction at Chatham.

By Henry Conybeare, F.G.S., M. Inst. C.E.

Lecture V.

On the Permanent Way of Railways.

In my present lecture I shall complete the subject of the engineering of ways of internal communication by considering what are the conditions that the permanent way of a railway ought to fulfil, and what is the best disposition of materials for satisfying such conditions. Under the present practice of executing colonial railways under government guarantee and supervision, it is peculiarly important that officers of the corps of Engineers should be correctly informed regarding the details of construction, on which the safety and efficiency of railway communication so much depends.

It is moreover a subject which has been greatly complicated by the pretensions of a host of rival patentees, most of whom have laid down a short trial length of their own patent system on some railway or other, from the engineer of which they can produce a certificate that it answers well. Such certificates really prove nothing at all, for they do not enter into the question of cost, nor can such short trials solve that of durability. And these are the only real questions; for almost any system, if laid down with the care and with the selection of materials with which a short and sample length is sure to be laid down by its inventor, will produce a road that will continue efficient for some short time after its completion, yet such certificates have considerable weight with non-experts, who are farther confused by the usual practice of such patentees of advocating their own patent system by depreciating, and attributing defects to, every other system in use, which defects have generally no existence save in their own imagination.

The multiplicity of the claims embraced in these patents occasions considerable inconvenience to engineers, for they comprise almost every practicable disposition of materials, and though very few indeed of these patents could be maintained in a court of law, yet as they have been for the most part bought up and worked by a company composed of a compact phalanx of railway engineers, who combine to advocate their adoption and to prosecute all who resist their claims, few railway companies think it worth while to contest them, especially as each of the great systems of permanent way may be laid down with a degree of perfection that leaves little to be desired, without trenching on any of such patent claims.

In the introductory lecture to the present course I stated that the golden rule to be observed in setting about any work was, first, to know clearly and thoroughly what it really is that you have to do, and then thoroughly to consider and determine how to do it in the best way that under existing conditions may be practicable, so as to avoid all purposeless labour, and to obtain a maximum useful effect.

Let us therefore in the first instance establish the conditions that a perfect system of permanent way ought to fulfil, and then apply the standard so provided to the various systems that have been introduced, and so determine what arrangements will best satisfy the required conditions.

The principal conditions that should be fulfilled by a perfect system of permanent way are as follows:—*

1. That the maximum weight and speed, and consequent damaging power of the engines and rolling stock employed, should be ascertained, and considered as the datum for calculating the requisite scantlings and disposition of the materials of the permanent way in each particular case.

2. *Bearing of the wheel on the rail.*—That the upper or bearing surface of the rails should present to the tread of the wheels a surface of sufficient width, and sufficient hardness and tenacity of texture not to laminate under the concentrated pressure and violent impact of the driving-wheels.

(The breadth of head of the rail usually varies from 2½ to 2¾ inches, the latter being the dimension generally adopted in recent continental lines.)

3. *Bearing of the rail on the sleeper.*—That the lower surface of the rail must be sufficient, either by its own width or by some artificial extension of width—such, for example, as chairs supply—to prevent it from crushing into the sleepers.

(The bearing of the chair or of the flat-footed rail on the transverse sleeper is usually 4 inches by 10 at each bearing, which is equal with 3-feet bearings to 40 square inches per yard per rail, and this is found sufficient to prevent any crushing of the timber, where the fastenings are such as to preclude any loose movement or hammering action between metal and timber. A considerable portion of the original permanent way of the South Western Railway, laid eighteen years ago, is on transverse sleepers 5 feet apart, and in this case the bearing of the chairs on the sleepers is only 40 inches for each 5 feet, equivalent to only 24 inches per yard per rail.)

4. *Bearing of the sleeper on the ballast.*—That the rails must have such an amount of bearing surface below them, either by their own structure (as in Barlow's saddle-back rail) or by the intervention of a substructure of sleepers, of sufficient area to prevent their crushing into the ballast on which they may be laid.

(The total area of a sleeper 10 inches wide by 9 feet is 1080 square inches, of which half or 540 inches pertain to each rail. Were the whole of this effective the bearing of the sleeper on the ballast would be for a 3-feet bearing 180 square inches per foot, equivalent to a continuous bearing of 15 inches. For a 5-feet bearing 108 square inches per foot, equivalent to a continuous bearing of 10·8 inches. But in practice it is only usual in laying transverse sleepers to pack 18 inches on each side of the rail, or 6 feet for both rails, which is two-thirds the length and area of the sleeper. The effective bearing will be therefore for a 3-feet bearing 120 square inches per foot, equivalent to a continuous bearing of 10 inches. For a 5-feet bearing, 72 square inches per foot, equivalent to a continuous bearing of 6 inches.

Greave's spheroidal sleepers present to the ballast a surface equivalent to a continuous bearing of 10 inches wide. De Bergue and Burleigh's cast-iron sleepers present to the ballast a surface equivalent to a continuous bearing of 9 inches wide. The bearing surface of the longitudinal sleepers of the Great Western Railway is continuously 14 inches wide.)

5. *Bearing of the ballast on the subjacent material.*—That the quality and depth of ballast below the sleepers may be adequate to distribute the weight and impact of the passing load over an area of the subjacent material sufficient to bear it without yielding; and that the sustaining capabilities both of ballast and subsoil be maximised by efficient drainage.

(The thickness of ballasting requisite for the fulfilment of this condition varies from 18 to 24 inches, according to the quality of the ballasting and subsoil.)

6. That the rails should possess so much vertical stiffness *and no more* as would confine their deflections under the passing load within unobjectionable limits. A certain amount of elasticity is essential to the durability of the rails, as an excess of rigidity invariably destroys the surface of the rail by acting as an unyielding anvil placed beneath it, between which and the hammering action of the driving-wheels the bearing surface of the rail is rapidly beaten out into laminæ, and so destroyed.

(A double-headed rail of 75 lb. per yard with 3-feet bearings is considered by the highest authority the heaviest and most rigid that it is expedient to use, even under the most heavy and rapid traffic. To give a rail any greater amount of stiffness

* Some of these conditions are taken from a paper read by Mr. Adams at the Institution of Civil Engineers, in February 1852.

Digitized by Google

than this is to deprive it of the degree of elasticity that is essential to prevent the lamination and rolling out of its bearing surface. Many high authorities consider even this too rigid: the rails most remarkable for their longevity have been far less rigid.

7. That the rail should possess sufficient lateral stiffness and hold on the substructure, and the substructure a sufficiently firm hold in the ballast, to prevent any lateral movement from the side lurches of the engine or train.

8. That the rails should be as smooth as possible on the running surface, to prevent concussion, and laid with a uniform cant inwards, exactly corresponding with the coning of the wheels; the gauge or clear distance between the rails being everywhere most accurately maintained; and the curves regularly bent, so as to insure the accurate tread of the wheels; while the joints of the rails should be so made as, while permitting contraction and expansion in each length of rail, should enable them throughout their whole aggregate length to approximate as nearly as possible to the conditions of a continuous bar, preserving equal strength and elasticity throughout. For if the joints be either more or less yielding than the intermediate portion, such sudden increment or decrement of resistance under the passing load will approximate to the conditions of a blow, and prove most injurious to the durability both of permanent way and rolling stock.

9. And all the fastenings of the rails to each other, of the rails to the chairs, and of the chairs to the sleepers, should be of such description as to permit of no shake or loose movement, which might induce hammering, and detraction of the permament way and rolling stock.

Prof. Willis has remarked, that in the absence of the proper technical knowledge derivable from theory or experiment a new machine will only arrive at its perfect and ultimate form through a series of abortive attempts, which by a succession of failures and repairs may perhaps lead to the removal of the weak points of the contrivance; and that those parts which by chance were at first made unnecessarily strong and heavy will probably retain their original error.

In any ordinary machine such an excess of strength in any of its parts would be objectionable only on the score of expense, but in the case of a "permanent way" such excess of strength and rigidity will often most materially detract from the durability of the structure, by reducing its elasticity under the impact of the wheels to an extent incompatible with the preservation of the bearing surface. It is therefore manifestly worse than useless to add to the strength, and consequently to the rigidity, of any part of the permanent way, unless experience has shown by a succession of failures that such portion of the structure has broken down under its work; and even then we must not resort to a mere increase of scantling as a remedy for the evil, until, by investigating the *modus operandi* of the damaging cause we have ascertained that it is to a deficiency of scantling alone that the failure is due.

For example, the first rails laid down on passenger lines were only 45 lb. to the yard, and proved too light for the speed and amount of traffic and consequent weight of the engines, all of which turned out much greater than had been anticipated. The best form of rail was thereon experimented upon, and new sections adopted varying from 60 lb. for 3-feet bearings to 75 lb. for 5-feet bearings, the strength in each case being somewhat over 7 tons. This answered very well till the railway revival of 1845, when the large augmentation of traffic, the introduction of express speeds, and the great and sudden increase in the weight of engines, due to the foregoing causes and to the rivalry between the broad and narrow gauges, proved more than the permanent way then in use (the joints and fastenings of which were not nearly so perfect as they are made at present) was able to resist: the bearing surface of the rails was crushed into laminæ, and destroyed, and the concussion thereby induced shook and hammered the structure to pieces. It was supposed that this failure would be remedied by simply increasing the weight of the rail; the weight was consequently increased, till in 1849 rails of 92 lb. on transverse bearings 2 ft. 8 in. apart were adopted on some lines, and rails of 100 lb. a yard with 3-feet bearings recommended; and had not the price of rails been then exceptionally high, it is probable that a considerably higher limit would have been attained.

But it was soon shown that these heavy rails were far shorter lived than their predecessors, whose real defect had been, not so much a deficiency of scantling, as defective joints, loose fastenings, and a want of hardness and homogenity of texture in the bearing surface of the rail; the more concentrated pressure and more violent impact to which they had lately been exposed having exceeded what the material was able to endure without being crushed into itself. The weight of rails was therefore again reduced, and at the present moment, notwithstanding the exceptionally low price of rails (only £6 per ton cash) no engineer of any authority would recommend for the heaviest and fastest traffic a stiffer way than is afforded by a double-headed rail 5 inches deep, and weighing 75 lb. the yard on 3-feet bearings; and some of the highest authorities are of opinion that a double-headed rail of similar depth, but of 70 or 71 lb., with 3 ft. 5 in. bearings, is adequate to any traffic that can be brought on a railway.

Let us now proceed to consider the nature of the various damaging influences exerted by the wheels of the engine and of the rolling stock on the rails, and how they may be best resisted.

The wear and tear of the permanent way is composed of that of the rails and that of the sleepers.

The durability of the sleepers depends solely on their intrinsic qualities, and the vicissitudes of moisture and temperature to which they are exposed, and is altogether irrespective of the amount of traffic carried upon the road.

The durability of the rails, on the other hand, is altogether independent of time, and exclusively consequent on the quantity of work they have performed, or on the quantity of ill usage they have sustained; just as the duration of a grindstone is dependent on the number and nature of the tools that have been ground upon it.

There are three complaints that are fatal to the life of rails:—the first is the waste of substance from the bearing surface, caused by the attrition of the wheels of the engine and rolling stock;—this is fair honest wear, and a rail that succumbs to this cause alone may be considered to have died a natural death. Rails would however withstand this attrition longer could their bearing surface be rendered harder.

The second cause that is fatal to the life of the rail, is the destruction by lamination under crushing pressure of the structure of its bearing surface: the rail becomes uneven, a hammering action of the wheels is thus induced, and the rail is split, bent, and beaten out, until unfit for use. This source of destruction is due to over rigidity in the rail or substructure; to the use of too soft a quality of iron for the bearing surface, and too great a weight on the driving-wheels, or to defects in the joints and fastenings, or irregularity in the laying exposing the rails to violent blows from the side lurches of the engine and carriages. This is the most frequent cause of the death of rails.

The third cause of destruction is a want of sufficient rigidity: the rail deflects under the load beyond the limits of elasticity, and takes a set: the surface becomes like a ridge-and-furrow field, the wheels at high speed leap from one prominence to the next, striking a succession of violent blows that soon prove fatal. Rails seldom perish from this cause unless they have been previously weakened by the crushing and beating out of their surface.

The waste of substance of the rails from the attrition of the wheels of the engine and rolling stock has been very exactly ascertained by M. Alphonse Belpaire, whose very elaborate and voluminous 'Traité des Dépenses d'Exploitation aux Chemins-de-fer,' was published by order of the Belgian government in 1847. The Belgian railways having been constructed by the state, and worked under government superintendence, the official reports regarding them present a mass of statistics much more comprehensive and more carefully elaborated than would be obtainable under ordinary circumstances. Dr. Lardner, in his 'Railway Economy,' has drawn largely on M. Belpaire; and the following abstract of the Belgian experiments is principally taken from that compilation:—

Rails laid under various circumstances and in various positions on the Belgian railways have been previously weighed with great accuracy, and being taken up after the lapse of a certain time have been again weighed, and the loss of weight ascertained; the quantity of work performed meanwhile having been accurately recorded. The result has been that a railway composed of well manufactured rails weighing 55½ lb. to the yard, and giving passage annually to 3000 trains of 14 waggons or coaches per train, would last 120 years before it required to be relaid.

The rails from which these calculations have been deduced were of English manufacture, and they were taken in every variety of position which could be supposed to influence the rate of their wear: some from near a station, where the action of the break

Digitized by Google

in stopping the train, and that of the driving-wheels in starting, necessarily augmented their wear; some from intermediate positions between station and station; some were taken from ascending and some from descending gradients, so as to efface from the calculation by the various conditions of the data the peculiar influences of each variety of position, and to obtain an average result.

The Belgian engineers have carried their investigation farther, and have endeavoured to ascertain the proportion of the wear assignable to the engine, the vehicles that it draws, and the loads. M. Belpaire has accordingly made an elaborate investigation founded on the theory of the action of the driving-wheels of the engine, and the effect produced by the weight of the carriages, and by the increased tractive power exacted from the engine; and after a long and complicated calculation has arrived at the conclusion, that in passing over ten myria-metres or about 60 English miles the engine abrades from the rails 2·2 lb., each empty carriage or waggon 4·5 oz., and each ton of load abrades 1·4 oz. of iron; the wear produced by each object being in direct proportion to its weight, the engine and tender weighing about 25 tons, and the average weight of the vehicles of transport being about 3 tons each unloaded.

Dr. Lardner has pointed out how closely M. Belpaire's results coincide with those independently obtained by Capt. Huish, in his investigation regarding the durability of the permanent way in use on the North Western Railway system. Captain Huish states in his report that the then average age of the permanent way was 7½ years; and that, all things considered, the reporters were of opinion that its total duration might be estimated at 20 years, thus leaving 12½ years of its present life to run. The weight of the rails was chiefly 75 and 65 lb. per yard, the average number of the trains 50 daily=18,250 per annum, and this being continued for 20 years (the duration assigned by Capt. Huish to the permanent way) we should have a total of 365,000 trains as the traffic necessary to wear out the line, and render necessary its reconstruction.

Now according to the conclusion of the Belgian engineers, 3000 trains per annum would wear out the Belgian lines in 120 years, which would give a total amount of work of 360,000 trains for the entire existence of the road. The Belgian rails were 55 lb. to the yard, the North Western rails ranged between 60 and 80 lb., the average being 70; but on the other hand, the weight and velocity of the English trains is proportionately greater than on the Belgian lines, so that the coincidence of M. Belpaire and Capt. Huish's independent conclusion is not disturbed by the difference between the weight of the rails. It may therefore be calculated with a traffic equal to 50 trains a day, 70-lb. rails will have a duration of 20 years, after which the entire line must be renewed.

It appears from these experiments that very few English rails die a natural death from fair waste of substance, but that they generally perish from the second of the three causes I have enumerated, viz., from the destruction of the bearing surface by lamination under the crushing pressure of the wheels due to over rigidity in the rail or its substructure, or to the bearing surface being too round in section, or to too soft a quality of iron, or to too great a weight on the driving-wheels; or to looseness and irregularities in the joints, fastenings, or laying, exposing the rails to violent shocks both lateral and vertical.

In ordinary cases of engineering, when a structure of given material is designed for the purpose of carrying a load, we first ascertain the amount of such load, and secondly the ultimate strength of the material, and having done so, we allow an ample margin for safety. For example, the ultimate strength of wrought-iron being 25 tons per square inch, the load on a wrought-iron girder bridge is not allowed to exceed 5 tons per square inch. But it is unfortunately impracticable to apply this rule to the apportioning of the bearing surface of the rails to the load on the locomotive driving-wheels; the case is a wholly exceptional one in engineering, for not even the smallest margin for safety is practicable; we cannot avoid loading the bearing surface up to or even beyond its ultimate strength; for the point of contact of the wheels with the rail (supposing the material of both to be unyielding and non-elastic) would be not a surface at all, but merely a mathematical point, and the load on the driving-wheels of a locomotive is often 11 tons. The only circumstance that can save the bearing surface from destruction under such circumstances is the elasticity of the wheel and the rail, which allows the periphery of the former to flatten at its contact with the rail, and the rail surface to lap round the contact of the wheel, so as to convert what would otherwise be a bearing point into a bearing surface; and it is obviously desirable to encourage this action as much as possible by giving the rail as much elasticity and as flat a bearing surface as is compatible with the observance of other essential conditions.

It is stated by experimenters, that the limit of weight that can be borne by the best wrought-iron before it begins to be crushed is 11 tons to the square inch; and it has been stated that rail iron begins to crush under a pressure of 8 tons to the inch. Now the weight under a pair of driving-wheels is often over 11 tons, or 5½ tons on each rail, supposing the weight quiescent.

And it appears from Barlow's experiments "that with a permanent way in really good order, with firm well-ballasted substructure, *i.e.* chairs well fixed and joints well made, the road itself being firm," the single rail is only deflected at the greatest velocity a little more than is due to the quiescent load equal to half the weight on the two wheels; but that in consequence of the imperfection of these parts a strain is occasionally thrown on the rail which produces a deflection about double that which belongs to the load in question, or in other words, whole load on one way: this effect was frequently and obviously exhibited in the experiments with the train. In many cases the deflectometer showed only the common amount of deflection when the engine (by far the heaviest load) passed over; whereas, perhaps in the middle or at the end of the train, a waggon would lurch over from some irregularities, and throw up the index to double its former amount.

(To be continued.)

HOUSE, MIDDLETON ROAD, CAMDEN ROAD, HOLLOWAY.

(With an Engraving.)

THIS picturesque house has lately been erected in the Middleton-road, Holloway. It is built of brick, with stone angle window to drawing-room. The roof and chimney pots are of slate; the hall, hearths, and skirtings throughout are of Maw's tiles. There is not any internal paint, the doors, shutters, staircase, and other joinery being of yellow deal, varnished; the walls are plastered and coloured. Plate glass is employed in the windows to principal rooms; and oak finger-plates and handles to doors are adopted throughout. Under the whole of the house there is a bed of concrete. The total area of the building is 25 feet by 28 feet. The architect is Mr. George Truefitt, of Bloomsbury-square, London, who designed the house for his own residence.

References to Plans.

Ground Floor.	*First Floor.*
A. Hall.	H. Drawing-room.
B. Dining-room.	I. Bed-room.
C. C. Water-closets.	J. J. Stairs.
D. Kitchen.	*Second Floor.*
E. Stairs.	K. K. K. Bed-room.
F. Scullery.	L. Closet.
G. Larder.	M. Stairs.

THE LATE MR. BRUNEL.

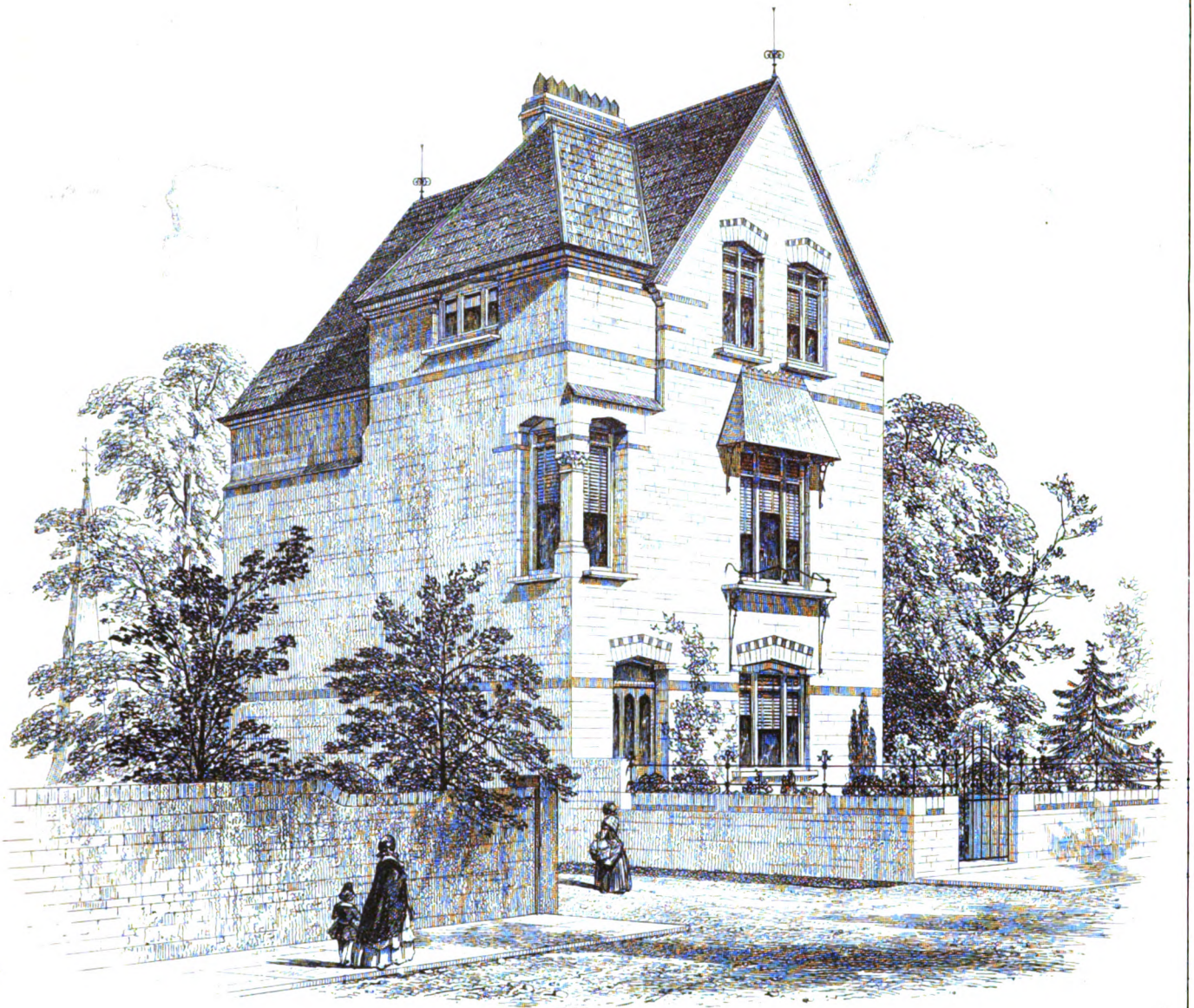
TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—I see that in your last number, in recording the death of the late excellent and talented engineer, Mr. Brunel, you observe that "it was under Mr. Brunel's auspices that the first screw-ship in the British navy was fitted up."

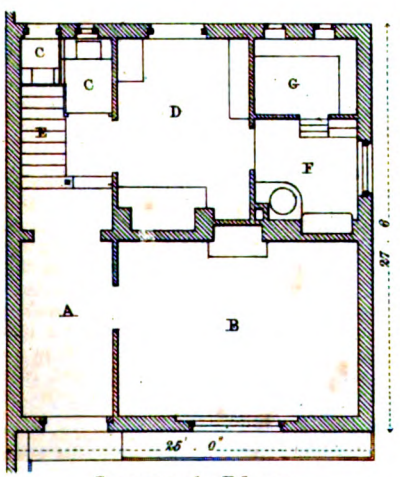
Now with every possible respect for Mr. Brunel's great merits as an engineer, I beg leave to observe, that the first screw-ship in the British navy was not fitted up by Mr. Brunel. This was done by my brother, Mr. Rennie, and myself, who made the Dwarf for the Admiralty, in the spring of 1840, which was the first screw-vessel introduced into the British navy, and succeeded perfectly. We also strongly recommended the Admiralty to at once employ the screw for propelling line-of-battle and every other class of vessels, which has since been done; and I believe that it was only subsequent to this that Mr. Brunel, as well as many other engineers, seeing the success of the screw as a propeller, became warm advocates of it, and adopted it. In vol. x. of your Journal, page 146, you will find a short history of screw propelling, with the merits of Mr. T. P. Smith, and other inventors of screw propelling, also an account of the Dwarf and the Archimedes (the engines, machinery, and screw of which were made by us in 1839), and this was I believe the first large vessel to which the screw was applied successfully as a sea-going ship. The account above alluded to will corroborate what is here stated.

Spring-gardens, 26th October, 1859. JOHN RENNIE.

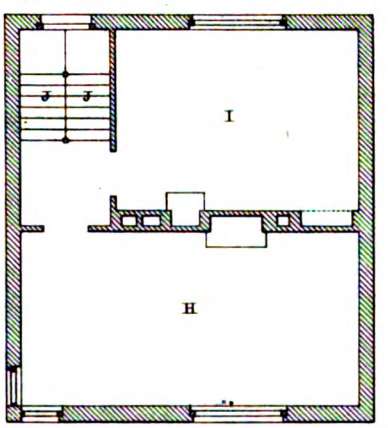
Digitized by Google



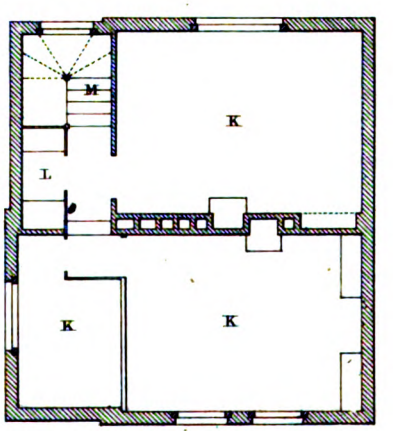
HOUSE, MIDDLETON ROAD, HOLLOWAY.
G. Truefitt, Archt.



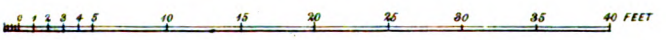
Ground Plan.



First Floor Plan.



Second Floor Plan.



Nov.r 1859

J.R.Jobbins

Digitized by Google

Digitized by Google

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Twenty-ninth Annual Meeting, held in Aberdeen, 1859.

(Continued from page 324.)

On Experiments to determine the efficiency of Continuous and Self-acting Brakes for Railway Trains. By WILLIAM FAIRBAIRN.

Of late years various improvements have been introduced upon railways to diminish the dangers of travelling, and attention is now specially directed to the increase of the retarding power for trains by various kinds of brakes. From an early period in the history of railways it was seen that few objects were more important for insuring the security of passengers, and reducing the loss of time occasioned by stoppages, than the attainment of some means of destroying the momentum of trains with ease and rapidity: that is, in the least time and in the shortest distance. The less the time requisite to break a train, the longer the steam may be kept on in approaching a station, and the less is the loss of time in stopping. And the shorter the distance in which a train can be brought to a stand, the less danger is there of collision with obstructions on the line perceived not far off ahead. It is already allowed by many of those connected with railways, and has been expressly stated by the Lords of the Committee of Privy Council for Trade, that the amount of brake power habitually supplied to trains is in most cases insufficient, and their lordships enumerate thirteen accidents from collision occurring in 1858 the character of which they consider would have been materially modified, if not altogether prevented, by an increased retarding power under the command of the guards of the trains.

Upon this subject the most important communication hitherto made has been the report prepared by Colonel Yolland for the Railway Department of the Board of Trade, and containing a large number of experiments with heavy trains at high velocities. The brakes with which Colonel Yolland experimented were those which, as improvements on the common hand-brake, have hitherto commanded most success. These were the steam-brake of Mr. McConnell, the continuous brake of Mr. Fay, the continuous and self-acting brake of Mr. Newall, and the self-acting buffer brake of M. Guerin. The general conclusions to which Colonel Yolland was led by his experiments resulted in the recommendation of the brake of Mr. Newall; and for heavy traffic a provisional recommendation of the brake of M. Guerin.

From a misunderstanding caused by this report of Colonel Yolland arose the necessity for some further experiments on the similar brakes of Mr. Fay and Mr. Newall; and these I was called upon to arrange and carry out by the directors of the Lancashire and Yorkshire Railway. I propose to lay before the association a brief abstract of these experiments, with some remarks upon the conclusions to which they gave rise.

It will not be necessary here to describe minutely the details of the construction of these brakes. They consist essentially of a series of brake blocks acting upon every wheel of the carriages of the whole train or some part of the train, the brake blocks being suspended as flaps, or placed on side bars beneath each carriage, as in the ordinary arrangement of the guard vans. But whereas it would be both expensive and inefficient to work these brakes with a guard or brakesman to each carriage, both Mr. Fay's and Mr. Newall's patents provide for a continuous shaft, carried the whole length of the train beneath the framing, and with suitable jointed couplings between each pair of carriages, so that they may be undisturbed by the rocking motion of the train or the action of the buffers. In this way the whole of the brakes may be worked by a single person at either end of the train communicating his power to each brake through the agency of the continuous shaft.

Again, there have been applied, in the first instance by Mr. Newall, and subsequently by Mr. Fay, powerful springs beneath each carriage, connected with the arms of the rocking shaft, by means of which the brakes are made to act instantaneously throughout the train, on the release of a catch or disengaging coupling in the guard's van. The value of this provision for the immediate and simultaneous action of the whole of the brakes, in cases where an obstruction is perceived upon the line, will be at once evident. It is one of the most important features of these brakes.

In carrying out the views of the directors of the Lancashire and Yorkshire Railway Company, it was arranged, in order to test the relative efficiency of these brakes, to have a series of experiments upon the Oldham incline of 1 in 27. On this gradient a train of carriages fitted with Mr. Newall's self-acting slide brakes, and a similar train fitted with Mr. Fay's continuous flap brakes, were started in turn, and after having passed over a measured distance by the action of their own gravity the brakes were applied, and the distance along the incline in which the trains were respectively brought up was carefully ascertained, as a measure of the retarding force of each. The trains employed consisted of three weighted carriages each, and having been placed upon the incline, they were started by removing a stop. Having then descended a previously measured distance with a uniformly accelerating velocity, they passed over a detonating signal, which conveyed notice to the guard to put on the brakes. Then the train having been brought to a stand, the distance from the fog signal to the point at which the train stopped was measured, and the train brought back for another experiment. In this way it was easy to obtain an initial velocity of 50 feet per second, or 35 miles an hour, before applying the brakes.

Unfortunately the day upon which these experiments were made proved misty and foggy, with rain at intervals, so that the rails were in the very worst condition for facilitating the stoppage of the train. The significance of this fact will be seen on comparing the retarding power of the brakes in these experiments with those made in fine weather.

Reducing the results, we find that the retarding force exerted by each brake in terms of a unit of mass, was equivalent to the numbers in the following table:—

Experiments on the Oldham Incline.

Mr. Newall.			Mr Fay.		
Velocity of train in feet per second.	Time in stopping, in seconds.	Retarding force of brake.	Velocity of train in feet per second.	Time in stopping, in seconds.	Retarding force of brake.
25·71	14	1·32	25·71	13	1·91
30·	16	1·63	30·	13	1·79
37·5	17	1·70	37·5	14	1·84
42·85	25	1·69	41·37	15	1·76
42·85	14	2·01	40·66	12	2·02
48·38	19	1·78	48·38	25	1·72
52·94	17	2·04	50·	17	1·91
Mean . .	21·6	1·74	Mean . .	19·2	1·85

The general result of these experiments gives a retarding force of 1·74 lb. per unit of mass for Mr. Newall's brake, and 1·85 for Mr. Fay's. Or, in other words, Mr. Newall's brake exerted a retarding force of 121·3 lb. per ton weight of the train, and Mr. Fay's a retarding force of 129 lb. per ton.

I afterwards arranged for some further experiments at Southport, upon a piece of level rail between that town and Liverpool. The speed requisite in this case had to be obtained by the aid of an engine, which was detached by a slip coupling at the instant of applying the brakes. In other respects these experiments were conducted like the preceding, with fog signals, and the time noted by stop watches. The weather, however, was in this case fine and dry, and hence the following results were obtained in the most uniform circumstances.

The friction of the train itself, and the resistance of the air, was ascertained to amount with Mr. Newall's train to 6·4 lb. per ton, and with Mr. Fay's train to 10·4 lb. per ton.

Experiments at Southport.—Slide Brakes: Engine detached.

Mr. Newall.			Mr. Fay.		
Speed in miles per hour.	Distance of pulling up in yards.	Retarding force of brake.	Speed in miles per hour.	Distance of pulling up, in yards.	Retarding force of brake.
32·72	56⅜	6·77	35·29	56	7·97
36·73	77	6·28	43·9	98	7·05
43·9	136	5·08	50·	129	6·94
46·15	140⅜	5·42	54·54	144	7·4
52·94	205⅛	4·89	54·54	161⅜	6·59
54 54	192	4·66	37·89	97	5·3
47·37	260⅛	...	60·	204⅜	6·3
53·73	222	5·23	60·	214	6·03
63·16	273	5·55			
	Mean . .	5·49		Mean . .	6·7

Digitized by Google

In this case we have a retarding force per unit of mass equivalent to 5·49 lb. in Mr. Newall's brake, and 6·7 lb. in Mr. Fay's. Or, in other words, the retarding force of the slide brakes of Mr. Newall, from eight experiments, at velocities varying from 35 to 60 miles an hour, was equivalent to 382·6 lb. per ton weight of the train. The retarding force of Mr. Fay's slide brake from eight similar experiments, at velocities from 33 to 63 miles an hour, was equivalent to 466·4 lb. per ton weight of the train.

Flap Brakes—Engine detached.

Mr. Newall.			Mr. Fay.		
Speed in miles per hour.	Distance of pulling up in yards.	Retarding force of brake.	Speed in miles per hour.	Distance of pulling up in yards.	Retarding force of break.
50·	132⅝	6·75	51·43	158¼	5·98
50·	123	7·28	51·43	162⅝	5·82
51·43	192	4 93	54·54	184	5·79
	Mean. .	6·32		Mean. .	5·87

These experiments give for the retarding force of Mr. Newall's flap brake 6·32 lb. per unit of mass, and for Mr. Fay's 5·87 lb. Or, in other words, the retarding force of Mr. Newall's flap-brake, from three experiments at velocities varying from 50 to 51½ miles per hour, was equivalent to 440·3 lb. per ton weight of the train. The retarding force of Mr. Fay's flap-brakes, from three similar experiments, was 408·6 lb. per ton.

We may illustrate the general bearing of these experiments by estimating from an average of the whole experiments the distance required to stop a train fitted with these brakes, and detached from the engines:—

A train would be stopped at a velocity of

20	miles an hour in	. . . . .	23·4 yards
30	,,	,, ...	52·9 ,,
40	,,	,, ...	93 8 ,,
50	,,	,, ...	146 8 ,,
60	,,	,, ...	211·5 ,,

This last table exhibits in a very clear manner the advantages of this class of brakes, in which the whole weight of the train aids in destroying the momentum of the mass, instead of the weight of one or two guard-vans only. It may be impossible in long trains to apply these brakes to every carriage; but at all events, in the ordinary traffic, three times the present amount of brake power may be employed with ease.

On the score of economy, also, the system appears to encourage its application. From experiments which have been made it appears that the wear of the tyres is far more uniform and equal, because the springs may be so adjusted as not to cause the wheels to skid. The manager of the East Lancashire Railway states that with two trains running together between Salford and Colne, the carriages fitted with continuous brakes travelled 47,604 miles before the wheels required to be turned up; whilst an ordinary brake-van, running the same distance, had to have its wheels turned up three times in the same period, three-eighths of an inch being taken off each time.

Experiments at Southport.—Engine not detached from the Trains.

Mr. Newall.		Mr. Fay.		Remarks.
Speed in miles per hour.	Distance of pulling up in yards.	Speed in miles per hour.	Distance of pulling up in yards.	
33·96	124⅝	31·8	121⅝	
37·11	169⅓	33 96	137	Engine and tender.
41·86	221	41·8	192⅓	Tender brake applied.
		51·43	274	Tank engine.

It will be observed that on most through lines the trains travel on some portion of the distance at the rate of 60 miles an hour; and in the event of an obstruction half a mile in advance, a collision would be inevitable, unless the driver has the power and the presence of mind to act with promptitude. Now, at 60 miles an hour there is only 30 seconds, or half a minute, to effect that object, and it is quite impossible to apply the brakes, in their present state, before the train—in such a precarious position—is in actual contact. Assuming, however, that brakes upon the principle of Newall and Fay were attached to the engine as well as the train, and that the driver had the power of instantaneous application by liberating a spring, it is evident that, instead of the train dashing forward to destruction, the momentum might be destroyed in a distance of less than 500 yards, and that without injury to life or property. Besides, the application of the electric telegraph, which prevents on most through lines more than one train being on the line between the stations, is a great additional security, and that, united to the continuous brake applied to the engine as well as the train, would, when united to a more perfect system of signals, render collision next to impossible.

On the Performance of Steam Vessels, the Functions of the Screw, and the Relations of its Diameter and Pitch to the Form of the Vessel. By Admiral Moorsom.

At the last meeting of the Association at Leeds, a paper "On the Performance of Steam Vessels" was read, in which some account was given of the Erminia, a yacht belonging to Lord Dufferin, and I have now to present some particulars of her performance.

A return has been handed by Mr. McConnell to the "Steam Ship Performance Committee," of certain trials of the Erminia in Stokes Bay, on the 12th October last; and the following further particulars of that vessel and her engines will enable the members of the association to follow me in the description I am now about to give, and to check any errors into which I may have fallen:—

Length of water-line	92·20 feet
Breadth, extreme	22·66 ,,
Draught of water { F.	9·50 ,,
Draught of water { A.	12·90 ,,
Displacement, about	244 tons
Area of greatest transverse section	149·18 sq. feet
Diameter of screw	8 feet
Pitch of screw	13 ,,
Length	1·34 ,,
Extreme breadth of each blade	3·00 ,,
Area of blade, about	15·5 sq. feet
Immersion of periphery	2 5 feet
Diameter of cylinder	15 inches
Length of stroke	18 ,,
Area of fire-grate	14·124 sq. feet
,, fire-box	92·96 ,,
,, tubes	446 22 ,,
,, steam ports	12×1¼ inches
Diameter of blast pipes	4 ,,

The performance at the measured mile, being the mean of four trips, was as follows:—

Speed of vessel	6 knots
,, screw	6·72 ,,
Slip	10·66 per cent.
Revolutions per minute	52·37
Indicator horse-power by 8 diagrams	54·59
Mean pressure in boiler	51·80 lb.
,, in cylinder	32·07 ,,

I had written to Lord Dufferin in August, that I anticipated a speed of 6 knots from 90 horse-power, and that I had selected a coarser pitch than I should otherwise have preferred, in consequence of some difficulty in estimating the thrust, and that the slip might be about 21 per cent. The results show a much better performance, and I must now explain the data on which my calculations were based.

The resistance of the vessel at 6 knots in smooth water was first estimated by resolving the resisting surfaces into an equivalent plane surface, and deducing the specific resistance of form by an empirical application of the method of Don Georges Juan: this gave 2763·5 lb. It was, secondly, estimated by another empirical process, which I had found to answer within given limits of form, and was founded on Beaufoy's experiment: this gave a specific resistance of 1896 lb.

In the absence of experiments that can be depended on for determining the thrust of the screw, I considered it safest to adopt the larger resistance, and to take as large a diameter for the screw as would admit of its being effectually immersed, so that the thrust should not be broken; and 8 feet was selected.

Now, the pitch of a screw of 8 feet diameter, to produce a resultant thrust of 2763·5 lb. at 6 knots, is 13·37 feet. The pitch selected being 13 feet, the slip to balance should be 21·11 per cent. Then, how comes the actual slip to be only 10·66 per cent.? The answer to this is the key to the whole operation, and it is

Digitized by Google

this:—The direct thrust of the screw under the actual circumstances of the trial was 2122·7 lb., and the resultant was 1896·4 lb., and the difference of the ratios of their square roots is 10·66.

But 1896 lb. is also the specific resistance as estimated by the second method, and as the thrust calculated by an independent process comes out the same, within half a pound, the concurrence of the two seems to establish *that* as the actual resistance at the time of the trial. Such concurrence may not, however, be held to be conclusive. Figures are said to have sometimes a singular facility in producing pleasant results.

There are two modes by which these results may be tested, the one analytical, the other synthetical. I will begin with the first, and employ the other in elucidation. The effective power, or total resistance, from the actual power of 54·59 horse-power, or 1,801,470 lb. at 6 knots, is 2961·67 lb., which is thus distributed:

Specific resistance	1896	lb.
Equivalent of slip	315·67	,,
Resultant of absorbed power	750	,,
Total	2961·67	lb.

I have in this analysis, as in my former paper, classed under the general term "equivalent of slip," two distinct elements, which I must now separate.

The first is that portion of the effective power which overcomes the resistance of the water to the rotation of the blades of the screw, and which is sometimes called "lateral slip." The second is that portion of the effective power which is employed in pushing back the water to obtain a fulcrum.

The first is	204	lb.
The second is	111·67	,,
Making together the	315·67	lb.

The absorbed power is composed of—1st, the friction of moving the machinery; 2nd, the additional friction of the load; 3rd, the back-pressure (as we are dealing with a non-condensing engine) from the blast-pipes.

For the first we have	136·92	lb.
,, second	189·60	,,
,, third	423·48	,,
Making the total of	750	lb.

In order to give a clearer view of these elements I will reverse them and show the corresponding pressure upon the piston.

	lb.		Pressure on piston lb. per sq. inch.
Back-pressure	423·48	...	4·64
Additional friction of load	189 60	...	2·07
Moving friction	136·92	...	1·50
Resistance of water to rotation of blades	204 00	...	2·23
Slip in terms of effective power	111·67	...	1·22
Specific resistance of vessel	1896·00	...	20·78
Making the totals of	2961·67	and	32·44

The pressure on the piston by the diagrams is 32·07 pounds, showing a difference of 0·37, which may be considered near enough.

Now, if it be said that this is an arbitrary classification not resting upon known data, I reply, not altogether so. I have lying before me diagrams of back-pressure from 3·45 lb. per square inch on the piston, moving at 236 feet per minute, with a mean pressure of 67·56 lb., to 12·3 lb. per square inch on the piston, moving at 569 feet per minute, with a mean pressure of 65 lb.; the diameters of blast-pipes varying from $4\frac{3}{4}$ to $4\frac{1}{4}$ inches, and the relations of steam ports from $14 \times 1\frac{3}{8}$ inches to $12\frac{1}{2} \times 1\frac{1}{2}$ inches of area.

The Erminia's blast-pipes were 4 inches in diameter, the steam ports $12 \times 1\frac{1}{4}$, and the speed of piston 157 feet per minute, with a pressure of 32·07 lb. per square inch in the cylinder. The back-pressure of 4·64 lb. which results from the analysis is therefore probable, and consistent with experience.

The next element of additional friction arising from the load, viz., 2·07 lb. per square inch, is calculated upon the specific resistance of 1896 lb., and may be disputed, because there are no satisfactory experiments on the subject. It is an estimate, and may be in excess.

The next element of the pressure to move the machinery, viz., 1·5 lb. per square inch, is a little over the mean of certain trials made by my direction, of which the diagrams are before me, the maximum being 1·63 lb., and the minimum 1·14 lb. To this on reasonable exception can be taken.

The resistance to the rotation of the blades, 2·23 lb., is calculated upon the basis of such experiments as I have access to on the friction of water on iron, and on the effective periphery of the screw. For this element also more precise experiments are needed, and it must be considered an estimate only.

The slip, 1·22 lb., requires no elucidation, except that it is what remains after deducting the effect of the resistance to the rotation of the blades. The specific resistance, equal to 20·78 lb. per square inch on the piston, or in the convertible terms of 1896 lb. of effective power, may therefore be dealt with as a probable result; and if so, the power of the screw is needlessly in excess of any resistance the Erminia is likely to offer, and I have explained why it is so, viz., because it was designed to produce a thrust at about 21 per cent. of slip, about 50 per cent. greater than the resistance of the vessel in smooth water, which resistance, viz., 2763·5 lb., turns out to be 45 per cent. greater than the actual resistance. Hence the screw is capable of a thrust nearly double of what the Erminia requires in smooth water.

What, then, is the most suitable size and proportion of screw for this yacht? I believe it will be found that the diameter should be as large as is consistent with its being sufficiently immersed, but no larger, and that the pitch should then be such as to produce a thrust to balance the resistance under ordinary conditions at sea with a moderate slip. If the screw be 8 feet diameter, then, to produce a thrust of 1896 lb. at 6 knots, the pitch must be 9·18 feet, and the slip about $13\frac{1}{2}$ per cent. But under ordinary conditions at sea the resistance will be increased, and it is expedient to have a coarser pitch, in order that the thrust may balance the resistance without excessive slip. If we assume the specific resistance at a mean between the two calculated results before described, or 2329·75 lb., the pitch must be 11·27 feet; and when the thrust works up to this resistance, the slip will be about 20 per cent.

I must now draw attention to other trials of the Erminia, viz.: First, on the 27th September:

Speed of vessel	6·83	knots
,, screw	7·76	
Slip	10·75	per cent.
Number of revolutions	60·05	
Mean pressure in cylinder	45	lb.
Indicator horse-power	87·40	
Diameter of screw	8	feet
Pitch ,,	13	,,

The results alone of this trial were sent to me, and not the particulars; and I have no means of checking them. On comparing the speed with that obtained on the 12th October—viz., 6 knots, with 54·59 horse-power—it will be found to be less than it should be, viz., 6·83 knots, instead of 7.

Second, on the 28th September:

Speed of vessel	7·98	knots
,, screw	10·39	
Slip	23	per cent.
Number of revolutions	81	
Mean pressure in cylinder	46	lb. per sq. in.
Indicator horse-power	121·9	
Diameter of screw	7	feet
Pitch ,,	13	,,

In this case also I was only furnished with results. The speed comes out a little beyond what it should be compared with the conditions of 12th October, viz., 7·98, instead of 7·84 knots.

It will be seen that the slip is more than double of that which took place on the two trials with the 8-feet screw, on the 27th September and 12th October, and more than two per cent. greater than that which I had estimated as due to the thrust to balance the resistance of 2763·5 lb.

In a report to the Admiralty, by Admiral Ramsay, Mr. Nasmyth, and Mr. Ward, occurs the following passage:—"All the evidence received shows that, where a ship has very fine lines, a coarse pitched screw with comparatively small diameter gives the greatest speed." The language in which this proposition is couched and the condition by which it is guarded, prevent me in the absence of the evidence on which it is founded, from saying more than that I must doubt the conclusion till I see facts in its support. It seems to be quite at variance with the principle on which the action of the screw rests, but here is an example to bear out the proposition. Having received some particulars of the Erminia's passage under steam from Malta to Alexandria, from

Digitized by Google

the 7th to 9th of December, I may suitably introduce them here.

Speed of vessel (mean average)	6·50 knots
„ screw	9 87 „
Slip	34·2 per cent.
Number of revolutions	77
Pressure in boiler	60 lb.
Coal used in 45·5 hours	8 tons

These particulars are not sufficient to justify any deductions, and mere inferences might only mislead. There is no risk of being far wrong, however, in saying that the resistance in this passage must have increased in a greater ratio than the increase of speed would account for. The diameter of the screw, 7 feet, with the original pitch of 13 feet, accounts for the slip of 34·2 per cent. on the supposition only of an increased ratio of resistance.

The next vessel to which I must invite attention is the yacht of the Duke of Sutherland, mentioned in my former paper. Full particulars of the performance of the Undine at the measured mile in the Thames, on the 6th July 1858, in Loch Lochy on the 27th October, and in Loch Ness on the preceding day, have been laid before the Steam Ship Performance Committee by Mr. McConnell. The particulars of this vessel are—

Length of water-line	125 feet
Breadth, extreme	25 „
Draught of water { F.	8·6 inch
Draught of water { A.	11·10 „
Displacement, about	294 tons
Area of greatest transverse section	154·33 sq. feet
Diameter of screw	7·10 inch
Pitch, &c.	11·4 „
Length	1·4 „
Extreme breadth of blade	2·8 „
Area of blade, about	13 sq. feet
Immersion of periphery	1·8 inch
Diameter of cylinder	0·24 „
Stroke	0·15 „
Area of fire-grate	45 sq. feet
Plate surface	2·06 „
Tubes	820 „

The performance on the 6th July was—

Speed of vessel	9·26 knots
Screw	11·29
Slip	17·91 per cent.
Revolutions per minute	101·74
Indicator horse-power by diagrams	157·09
Mean pressure in cylinder	12·28 lb. ℔ sq. in.
„ from vacuum	10·70 „
Total pressure	22·98 „
Mean pressure in boiler	15·80 „

Now, the specific resistance of the Undine at 9·26 knots, estimated as the Erminia's, by the empirical rule founded on Beaufoy's experiments, is 3809·4 lb. By the synthetical method it is as under, viz.,

	Pounds per sq. inch.		Pounds in terms of effective power.
Moving friction	1·40	...	342·89
Additional friction for load ...	1·55	...	380·94
Resistance to rotation of blades ...	2·37	...	582·50
Slip in terms of effective power ...	1·65	...	405·10
Total less specific resistance ...	6·97	...	1711·43
Total pressure and effective power	22·51	...	5517
Specific resistance	15·54	...	3805·57

The difference between 3805·57 and 3809·4 is not material in estimates such as this. It will be seen also that there is a difference of 0·47 lb. per square inch in the aggregate pressure as compared with that given by the diagrams. So far the two methods are in harmony; but now I have to show a screw that is not so tractable.

The direct thrust at 11·29 knots is 7469·3 lb., and the slip being 17·91 per cent., the resultant is 5022·3 lb., or more than 31 per cent. greater than the resistance of the vessel. This, however, cannot be so, and the apparent excess must be accounted for. I have already said that the screw must be sufficiently immersed, in order that its thrust may be that which is due to its diameter and pitch. What is sufficient is yet an open question. The Erminia's was 2 ft. 6 in., the Undine's only 1 ft. 8 in.

I believe this to be the explanation of the anomaly. The apparent thrust 5022·3 lb. was really an effective thrust of only 3805·57 lb. in consequence of the rotation of the blade breaking up the surface of the water. This screw would produce, if sufficiently immersed, a resultant thrust of 3805·57 lb. at 9·26 knots, with a slip of 10·32, say 10½ per cent. The actual slip was 17·91 per cent. I have found the same results in several ships of war: in all whose screws are near the surface; in none whose screws are buried.

We have now reached one of the most interesting of the investigations, which, in my former memoranda, I pointed out as worthy of the attention of the British Association. This is an investigation by experiment not difficult to accomplish, and yet I conclude it has not had the consideration of the naval authorities, as they continue to give screws to their ships which are only immersed about one-fourth to one-eighth of their diameter, whereas the Erminia's was immersed about one-third, while the Undine's was about one-fifth. The due proportion of immersion will, I believe, be found to depend somewhat on the speed of rotation. I wish to guard myself against being misunderstood as to these estimates. They are rough approximations thrown out for the purpose of bringing to a practical issue the application of certain known laws of fluids. The application here is, as I have repeatedly declared, purely empirical. It is the result of the observation and experience of one who has no theory to advance or to support, but who, as a sea-officer, and as having also been actively engaged in the construction of some of the greatest public works of this country, and as being now occupied in the management of one of its largest commercial undertakings, has been in the habit of recording and classifying facts with a view to the induction of laws, and to bring within the sphere of scientific calculation what is generally determined by the sort of experience popularly called the "rule of thumb." He knows by experience that accuracy may be ensured and time and money saved by estimates, however rough, if based on ascertained facts as against opinions the most experienced; and he believes that the laws which govern the resistances of ships under various conditions may be ascertained sufficiently to guard against the mistakes of which every one concerned in shipping is aware.

There are two packets plying between Holyhead and Kingstown which have made that passage at the rate of nearly 19 statute miles an hour, and their displacement is only about 600 tons. When in 1846 those vessels were designed, though I had no responsibility in designing them, I told my colleagues that their speed might reach 20 statute miles an hour. That was not a guess, it was an estimate. It turned out however that the requisite length could not be given to them. One of these vessels is capable of making way against any head sea and wind short of a hurricane. In running before the wind she is uneasy, and requires nice management. The other cannot encounter a heavy head-sea like the first, but she scuds with ease and comfort. A seaman will give a reason for this difference, and probably he might be right; but I doubt if he could show how a vessel is to be designed so as to unite the two best qualities of each. Yet their union is practicable; and in the records from which are compiled the returns presented to the Steam Ship Performance Committee are the facts which would enable a scientific naval architect to effect that union.

A question may here be asked which I am not in a condition to answer. Has the speed of ships increased in the ratio due to their increase of size? Does the speed of the Mersey of 5462 tons, being about 13¾ knots, with 4044 horse-power, answer to the deductions of science when compared with the Rattler of 1078 tons, with a speed of about 9½ knots, with 436·7 horse-power? If not, there may be reasons why not; but I have failed to discover them. I think information on this point would be valuable to science.

I had intended to make some observations on the high-pressure engines in the gun-boats, but I must postpone them for a future occasion, with this remark,—That the high-pressure engines whose performance I have investigated are not fair specimens of their class; and any conclusions drawn from them, as to their suitableness for ships of war, must be inconclusive.

I have felt it to be due on my part to the British Association to bestow some pains on the matters submitted in this paper, not only as an acknowledgment of the ready attention paid to my suggestion in my absence, both last year and in Dublin, for the appointment of a committee, but also to show what may be done, and what there is to do. I trust I have shown that there is a practical issue before us worthy of the labour; that these are not the speculations of a theorist unversed in practical life, which however amusing in the closet can determine no actual issues, but that they have a vital bearing on questions which now exercise some of the keenest intellects of our day.

Digitized by Google

The science of war has, as we all know, called forth the most practical development of the human mind. At this moment all the resources of mechanical art are stimulated to the utmost to produce, or to perfect, instruments of war. Ships are in this category. Where are the admitted laws which are to guide us? Who can point them out? I therefore again suggest the renewal of the powers of the committee appointed at Leeds, with some extension of their objects.

I cannot close this paper without making some attempt to discharge the debt of acknowledgment on the part of science which I feel to be due to the two noblemen, whose experiments with their yachts have enabled me to make this exposition of what I conceive to be the principle of the screw in its relation to ships. Experiment can alone prove or disprove my positions. But in either event the Marquis of Stafford and Lord Dufferin are thankworthy, who at some cost have taken a course which seemed to have the sanction of science. Experiments of this nature ought to be undertaken by government—they, representing the nation, have the largest interest at stake, and the amplest means at command.

If it should turn out that the investigation here unfolded leads to determine the relations between the direct thrust of the screw and its resultant, and between that and the form of the vessel, one more instance will be added to the many our country offers of the value of voluntary associations in stimulating individuals in the pursuit of a common object; and I shall have some satisfaction in thus vindicating the claim to be considered a scientific sea-officer, to which I once fancied I had some pretensions, and to which I still attach some value. Nethertheless I should not have gone out of my way to make public such investigations as these which have amused my leisure hours, if it had not been for the British Association for the Advancement of Science.

On the True Action of what are called Heat Diffusers.

By Arthur A. Taylor, of Marseilles.

Mr. Wye Williams and others have found that an increased effect was produced by the fuel burnt in steam boilers when what have been called heat-diffusers were placed in the tubes or flues. The apparatus in question consists generally of metallic bands or ribands twisted into spirals or bent in the direction of their length into zigzag forms, and placed in the tubes or flues. The professed object of this addition being to break up or disturb the current of heated gases passing through the tubes, and to cause every portion of the gases to impinge on the heating surfaces. The cause given for the increased effect produced being, that when a current of heated gases passes through a tube under ordinary circumstances, only the exterior portions of the column come in contact with the sides of the tube, and that in thus disturbing the current by obstacles to its direct course, a more perfect contact of the gases with the surfaces is produced. The question which I wish to raise is, whether this is the true explanation of the effect produced by diffusers, deflecting bridges, &c. I think it can hardly be admitted that each molecule of a gas passing through a tube follows a course parallel with the axis, for those in contact with the sides of the tube will be so impeded by friction as to have a much slower motion than those in the centre, just as in a river the current near the banks is less rapid than that in the middle of the stream; and that, as in the river, so in the tube, a series of eddies will be formed, tending to bring all portions of the gas in contact with the sides of the tube. This peculiar motion of gases in a tube may very clearly be observed in the smoke issuing from the funnel of a steamer, the smoke retaining the eddying motion which it had in the funnel for some time after leaving it. These considerations led me to consider the mere disturbance of the currents as inadequate to explain the increased evaporation observed, and to attribute it to a very different cause. Gases do not radiate the heat which they contain, so that the only mode in which a gas can communicate its heat to a surface is by contact or connection. This is in the present practice the only mode in which those heating surfaces of a boiler which are not exposed to the radiation of the fire or flame can abstract heat from the products of combustion; but if in a flue or tube a solid body be introduced it will become heated by contact with the gases, and will radiate the heat thus received to the sides of the flue. Now these diffusers, &c. exactly fulfil these conditions, and I therefore attribute their effect mainly, if not entirely, to the function which they must fulfil in absorbing heat from the gases by contact, and then radiating this heat to the sides of the tubes or flues; and I think it will be admitted that the amount of heat thus conveyed to the water may be very important, when it is considered that the temperature of the gases in the tubes of a boiler at 5 inches or 6 inches from the firebox tube plates is about 800 degrees Fah., and that these radiators will consequently have a temperature of several hundred degrees above that of the surfaces in contact with the water in the boiler, and that a very active radiation must consequently take place from one to the other. This principle once established, the modes of application in practice are, of course, endless; and I will only mention that I do not see any advantage in making these radiating surfaces of such a form as to impede the draught, especially in the case of marine boilers, but would rather choose the form which would give the greatest amount of radiating surface, and offered the least impediment to the free passage of the products of combustion through the tubes. Perhaps as effective a form as any for placing in the tubes of boilers would be a simple straight band of metal, or a wider band bent in the direction of its breadth at an angle of 60 degrees. In the case of marine boilers, they should be made so as to draw out easily, to enable the tubes to be swept.

Mercantile Steam Transport Economy. By Charles Atherton, Chief Engineer, Royal Dockyard, Woolwich.

Public usefulness, as dependent upon science, being the great object for which the British Association for the Advancement of Science was originated and has now been signally upheld for twenty-nine years, a period remarkable for the progress that has been made in the utilisation of the powers of nature, to such an extent that the international condition of the globe is now being revolutionised by the progressive practical utilisation of elements which heretofore were regarded merely as phenomena of nature, viz., Steam and Electricity; in which revolution the application of steam to the purposes of navigation has played so conspicuous a part, that now, in proportion as steam may be effectively employed in the pursuits of commerce and of war, it is acknowledged that even nations will rise or fall. Seeing, moreover, that at no period in the history of steam navigation has so great a step been made in its practical development as may now be said to have been realised, by the fearless introduction in marine engineering of the long known and well understood effects of increased pressure, superheating, and expansion; the recognition and application of which principles have now, at length, been attended with such effect in marine engineering, that the consumption of fuel with reference to power is now shown to be practically reducible to less than one-half of the ordinary consumption of coal on board ship. Seeing also that mercantile enterprise, setting no limits to speculative investments, has in these days emancipated mechanical intellect from the fetters by which ideas as respects magnitude have hitherto been bound; —under such circumstances I cannot doubt that any effort to popularise a knowledge of the practical utilisation of steam with reference to the consumption of fuel, though advanced with no pretensions to science beyond that which may be awarded to originality and labour in the application of calculation to developing useful results, will be favourably received, more especially as the paper which I now beg to present is in continuation and conclusion of an inquiry which has already in part, on two occasions, been favourably entertained by this association, and honoured with a place in its published records. The former papers to which I allude are:—1st, "Mercantile Steam Transport Economy, with reference to Speed" ('Transactions', vol. for 1856, p. 423). 2nd, "Mercantile Steam Transport Economy, with reference to the Magnitude of Ships and their Proportions of Build" (vol. for 1857, p. 112). And I now propose to bring this inquiry to its conclusion by the following paper on—

Mercantile Steam Transport Economy, as affected by the Consumption of Coal.

My purpose and the drift of my remarks will, probably, be the more readily understood by my at once adducing the tables C and D, and the diagram E, in continuation of the tables A and B which are published in the volume of 'Transactions' for the year 1857, pp. 116 and 119, observing with reference to these tables C and D, that the rate of consumption of coal on which the calculations are based, viz., 2½ lb. per indicated horse-power per hour, has been practically realised on continuous sea service, although the ordinary consumption of steam-ships in the royal

Digitized by Google

navy, as well as in the best vessels of the most celebrated steam shipping companies, is, I believe, at the present time fully 50 per cent. in excess of that amount; and I may say, that in steam shipping generally the consumption of coal per knot of distance, with respect to displacement and speed, is double the consumption which these tables, based as they are on an example of existing practice, show to be now practically realisable. The tables now adduced are as follows:—

Table C, calculated for the speed of ten knots per hour, showing the mutual relations of displacement, power, and the consumption of coal per day, per hour, and per knot, for vessels of a gradation of size from 250 tons displacement up to 25,000 tons, the co-efficient of dynamic performance, deduced from the formula $\frac{V^3 D^{\frac{2}{3}}}{\text{I.H.P.}}$ being assumed to be 250, and the consumption of coal being assumed to be at the rate of 2½ lb. per I.H.P. per hour. On these data, the co-efficient with reference to coal, deduced from the formula $\frac{V^3 D^{\frac{2}{3}}}{w}$, w being the consumption of coal per hour expressed in cwts., becomes 112·10.

TABLE C.

Displacement.	Nominal horse-power taken at the unit 100,000 lb 1 foot per minute.	Indicated horse-power taken at the unit 33,000 lb. 1 foot per minute.	Coal.		
			Per day of 24 hours.	Per hour.	Per knot.
Tons			Tons	Cwt.	Cwt.
250	52	159	4·26	3·55	·36
300	59	179	4·8	4	·4
350	66	199	5·33	4·44	·44
400	72	217	5·81	4·84	·48
450	78	235	6·3	5·25	·53
500	83	252	6·74	5·62	·56
600	94	285	7·63	6·36	·64
700	104	315	8 44	7·03	·7
800	114	345	9·24	7·7	·77
900	123	373	9·98	8·32	·83
1000	132	400	10·7	8·92	·89
1100	141	426	11·4	9·51	·95
1200	149	452	12·1	10·1	1·01
1300	157	476	12·7	10·6	1·06
1400	165	501	13·4	11·2	1·12
1500	173	524	14	11·7	1·17
1600	181	547	14·6	12·2	1·22
1700	188	570	15·4	12·8	1·28
1800	195	592	15·8	13·2	1·32
1900	203	614	16·4	13·7	1·37
2000	210	635	17	14·2	1·42
2250	227	687	18·4	15·3	1·53
2500	243	737	19·7	16·4	1·64
2750	259	785	21	17·5	1·75
3000	275	832	22·3	18·6	1·86
3250	290	878	23·5	19·6	1·96
3500	304	922	24·7	20·6	2·06
3750	318	965	25·8	21·5	2·15
4000	333	1008	27	22·5	2·25
4250	347	1050	28·1	23·4	2·34
4500	360	1090	29·2	24·3	2·43
4750	373	1133	30·2	25·2	2·52
5000	386	1170	31·3	26·1	2·61
5500	411	1246	33·4	27·8	2·78
6000	436	1321	35·4	29·5	2·95
6500	460	1393	37·3	31·1	3·11
7000	483	1464	39·2	32·7	3·27
7500	506	1533	41	34·2	3·42
8000	528	1600	42·8	35·7	3·57
8500	550	1666	44·6	37·2	3·72
9000	571	1731	46·3	38·6	3·86
9500	592	1794	48	40	4·8
10000	613	1857	49·7	41·4	4·14
11000	653	1978	52·9	44·1	4·41
12000	692	2096	56·2	46·8	4·68
13000	730	2211	59·2	49·3	4·93
14000	767	2324	62·3	51·9	5·19
15000	803	2433	65·2	54·3	5·43
20000	973	2498	79	65·8	6·58
25000	1129	3420	91·6	76·3	7·63

Table D (p. 363), showing the mutual relation of displacement, power, and coals consumed per day, per hour, and per knot for the respective speeds of 10, 15, 20, and 25 knots per hour. The data on which this table is calculated being the same as above described for table C.

Diagram E (p. 364), showing approximately by scale the nautical mileage consumption of coals for vessels from 1000 tons displacement up to 25,000 tons, deduced from table D.

It will be observed that in table C the tabulated sizes of ships, as determined by their respective load displacements, increase progressively from 250 tons displacement up to 25,000 tons, showing under assumed conditions, which however are justified by the present circumstances of realised advancement in steam navigation, the mutual relations of displacement and coal, calculated for the speed of 10 knots per hour, as most convenient for a standard of reference. The intended practical use of this table C is to facilitate mercantile investigation into the dynamic merits of steam ships as locomotive implements of burden, by comparing their actual consumption of fuel with the calculated consumption of the ship of corresponding size and speed as recorded in this tabulated standard of comparison, whence the constructive merit of ships as respects their *working economy of fuel, on which the cost of freight so much depends*, may be relatively ascertained. For example, a certain ship of 800 tons mean displacement attains the speed of 8·8 knots per hour, with a consumption of coal certainly not exceeding 4·3 cwt. per hour, or ·49 cwt. per nautical mile or knot; which (as the consumption of coal per knot varies *cæteris paribus* as the square of the speed) is equivalent to ·63 cwt. per knot at the speed of 10 knots per hour. Now by referring to table D we find that, on the assumed data therein referred to, the standard ship of 800 tons displacement, steaming at 10 knots per hour, would consume ·77 cwt. of coal per knot. Hence, therefore, it appears that the ship referred to in this instance is superior to the tabulated standard in the proportion of ·77 to ·63, that is, in the proportion of 122 to 100, the superiority with reference to the consumption of coal per knot being 22 per cent.

Again, a certain ship of 3500 tons mean sea displacement makes a voyage of the speed of 12·88 knots per hour, consuming 83 cwt. of coal per hour, or 6·44 cwt. per knot, which, by the law of dynamics above quoted, is equivalent to 3·88 cwt. per knot at the speed of 10 knots per hour; but by referring to the table of comparison C, we find that the standard ship of 3500 tons displacement, steaming at 10 knots per hour, would consume only 2·06 cwt. of coal per knot. Hence, therefore, it appears that the ship referred to in this instance is inferior to the tabulated standard ship in the proportion of 2·06 to 3·88, that is, in the proportion of 53 to 100, the inferiority with reference to the consumption of coal being 47 per cent.

Thus, by reference to this tabulated standard of comparison (C), we have the means of readily deducing the exact percentage by which ships, as respects the dynamic duty performed with reference to the consumption of coal, differ from each other. I need not dwell on the importance of this consideration as affecting the commercial value of ships.

With reference to table D, showing the mutual relations of displacement, power, and coal consumed per day, per hour, and per knot for the respective speeds of 10, 15, 20, and 25 knots per hour; the object of this table is to show the extent to which the required engine power and the nautical mileage consumption of coal are dependent on the rate of speed, thereby facilitating the adaptation of ships as respects their size and power to the service that may be required of them.

For example, by referring to table D we observe that a ship of 5000 tons displacement, steaming at 10 knots per hour, requires 1170 I.H.P., and consumes 2·61 cwt. of coal per knot; but to steam 15 knots per hour the same vessel would require 3947 I.H.P., and the consumption of coal would be 5·87 cwt. per knot; hence it appears, that to increase the speed from 10 to 15 knots per hour, the power requires to be increased upwards of three times, and the consumption of coal per knot is more than doubled.

Again, let it be supposed that the weight of the hull of a ship of 5000 tons displacement fitted for sea amounts to 40 per cent. of the displacement, or 2000 tons, and suppose the weight of the engine and boilers to be one ton for each I.H.P., the vessel requiring as shown by table D 1170 I.H.P. to attain the speed of 10 knots per hour, with a consumption of coal at the rate of 2·61 cwt. per knot; then on those data, the engines, to attain the speed of 10 knots per hour, would weigh 117 tons, and the weight of coal for a passage of, say 12,000 nautical miles, would be $12{,}000 \times 2{\cdot}61 = 31{,}320$ cwt., or 1566 tons weight, making together, for hull, engines, and coal, $2000 + 117 + 1566 = 3683$, and consequently the displacement available for cargo would be $5000 - 3683 = 1317$ tons

Digitized by Google

TABLE D.

Showing the Mutual Relations of Displacement, Power, and Coals consumed per Day, per Hour, and per Knot, for the respective Speeds of 10, 15, 20, and 25 Knots per Hour. The Coefficient of Dynamic Performance being deduced from the Formula $\frac{V^3 D^{\frac{2}{3}}}{\text{ind. h. p}}$ being assumed to be 250, and the Consumption of Coals being assumed to be at the rate of 2½lbs per indicated horse power per hour.

Displacement in Tons, at 35 cubic feet of Sea Water per Ton.	10 Knots.				15 Knots.				20 Knots.				25 Knots.			
	Ind. H. P.	Coals.			Ind. H. P.	Coals.			Ind. H. P.	Coals.			Ind. H. P.	Coals.		
		Per Day.	Pr Hour.	Pr Knot.		Per Day.	Pr Hour.	Pr Knot.		Per Day.	Pr Hour.	Pr Knot.		Per Da .	Pr Hour.	Pr Knot.
		Tons.	Tons.	Cwt.		Tons.	Cwt.	Cwt.		Tons.	Cwt.	Cwt.		Tons.	Cwt.	Cwt.
1,000	400	10·7	8·92	·89	1350	36·1	30·1	2·0	3200	85·7	71·4	3·57	6250	167	139	5·56
1,200	452	12·1	10·1	1·01	1524	40·8	34·0	2·27	3614	96·8	80·7	4·03	7058	188	157	6·28
1,400	501	13·4	11·2	1·12	1689	45·2	37·7	2·51	4005	107	89·4	4·47	7822	210	175	7·00
1,600	547	14·6	12·2	1·22	1847	49·4	41·2	2·75	4377	117	97·7	4·88	8550	229	191	7·64
1,800	592	15·8	13·2	1·32	1998	53·5	44·6	2·98	4735	126	105	5·25	9248	247	206	8·24
2,000	635	17·0	14·2	1·42	2143	57·4	47·8	3·19	5080	136	113	5·65	9921	265	221	8·84
2,250	687	18·4	15·3	1·53	2318	61·8	51·5	3·43	5495	146	122	6·10	10,731	286	239	9·56
2,500	737	19·7	16·4	1·64	2487	66·6	55·5	3·70	5895	158	132	6·60	11,629	308	257	10·3
2,750	785	22·0	17·5	1·75	2650	70·9	59·1	3·94	6281	168	140	7·00	12,268	328	273	10·9
3,000	832	21·3	18·6	1·86	28·8	75·2	62·7	4·18	6656	178	148	7·40	13,000	348	290	11·6
3,250	878	23·5	19·6	1·96	2962	79·3	66·1	4·40	7021	188	157	7·85	13,715	367	306	12·2
3,500	922	24·7	20·6	2·06	3112	83·3	69·4	4·63	7377	197	164	8·20	14,408	385	321	12·8
3,750	965	25·8	21·5	2·15	3259	87·2	72·7	4·85	7724	206	172	8·69	15,086	404	337	13·5
4,000	1008	27·0	22·5	2·25	3402	91·1	75·9	5·06	8064	216	180	9·00	15,749	421	351	14·0
4,250	1050	28·1	23·4	2·34	3542	94·9	79·1	5·27	8396	224	187	9·35	16,392	439	366	14·6
4,500	1090	29·2	24·3	2·43	3680	98·5	82·1	5·47	8722	233	194	9·70	17,036	456	380	15·2
4,750	1130	30·2	25·2	2·52	3815	102	85·1	5·67	9042	240	202	10·1	17,661	473	394	15·8
5,000	1170	31·3	26·1	2·61	3947	106	88.1	5·87	9357	251	209	10·4	18,215	488	407	16·3
6,000	1321	35·4	29·5	2·95	4458	120	100	6·67	10,566	283	236	11·8	20,637	553	461	18·4
7,000	1464	39·2	32·7	3·27	4940	132	110	7·33	11,710	313	261	13·0	22,870	612	510	20·4
8,000	1600	42·8	35·7	3·57	5400	145	121	8·01	12,800	342	285	14·2	25,000	670	558	22·3
9,000	1731	46·3	38·6	3·86	5841	156	130	8·67	13,846	371	309	15·4	27,042	724	603	24·1
10,000	1857	49·7	41·4	4·14	6266	167	139	9·27	14,853	398	332	16·6	29,010	778	648	25·5
12,000	2096	56·2	46·8	4·68	7076	190	158	10·5	16,772	449	374	18·7	36,760	877	731	29·2
14,000	2324	62·3	51·9	5·19	7842	210	175	11·7	18,588	498	415	20·7	46,305	972	810	32·4
16,000	2540	68·0	56·7	5·67	8572	229	191	12·7	20,320	544	453	22·6	39,684	1063	886	35·4
18,000	2748	73·6	61·3	6·13	9272	248	207	13·8	21,980	589	491	24·5	42,294	1150	958	38·3
20,000	2948	79·0	65·8	6·58	9948	266	222	14·8	23,580	631	526	26·3	46,048	1233	1028	41·1
22,000	3140	84·0	70·0	7·00	10,600	283	236	15·7	25,124	673	561	28·0	49,072	1314	1095	43·8
25,000	3420	91·6	76·3	7·63	11,542	310	258	17·2	27,359	733	611	30·5	53,436	1432	1193	47·7

weight. But if it be purposed that the steaming speed shall be at the rate of 15 knots per hour, the required power, as appears by table D, will be 3947 I.H.P., consequently the weight of the engines will be 395 tons, and the maximum displacement available for coal will be 5000—2395=2605 tons weight, or 52,100 cwt., which, at the tabulated rate of consumption, 5·87 cwt. per knot, would be sufficient only for a passage of 8876 nautical miles, and this to the utter exclusion of all goods cargo; showing that the ship is inadequate for steaming 12,000 nautical miles at the required speed of 15 knots per hour, though the same ship, if duly fitted with engine-power for steaming at 10 knots per hour, would perform the whole passage of 12,000 nautical miles without re-coaling at any intermediate station, and carry 1317 tons of remunerating goods cargo.

These few examples will, it is hoped, sufficiently illustrate the application and use of tables C and D in facilitating mercantile inquiry into the capabilities of steam-ships with reference to the all-important question of consumption of coal; but in order still further to facilitate calculations on this subject, the diagram E has been prepared, whence, simply by inspection, the consumption of coal per knot at any rate of speed may be approximately ascertained for vessels from 1000 tons displacement up to 25,000 tons, the data on which this diagram has been calculated being the same as that on which tables C and D are based.

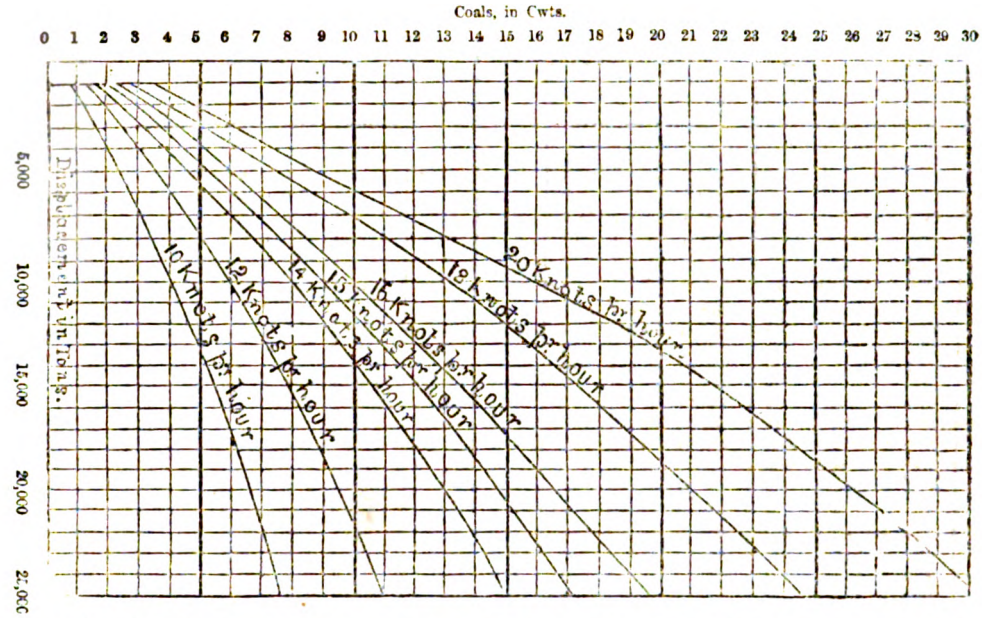
The use and application of this diagram E is evident; it brings the tables under ocular review, and generalises their application. It is given as an example of a system that admits of being more fully and elaborately developed for the purposes of mercantile tabular reference, as is now being done for publication.

Having thus explained the use and application of tables C and D and diagram E, it will be perceived that the task which I have undertaken on this occasion is to show palpably, by comparison with these tabular statements, based on data within the limits of already realised results, taken as a standard, what is the character of steam-ships as respects their locomotive or dynamic capabilities, with reference to the economic performance of mercantile transport service, so far as dependent on the consumption of fuel, thus affording an exposition whereby persons interested in steam shipping, either as owners or directors or agents, or as charterers of shipping for government or for private service, though unacquainted with the details of marine engineering as a science, may be enabled to arrive at some definite appreciation of the amount of work that may be expected of steamers; that is, the weight of cargo they will carry, and the length of passage capable of being performed at any definite speed, for, as before observed, the dead weight of cargo that a ship will carry is equal to the tons weight of water displaced between the light and load water-lines of the ship, less the weight of coal required for the voyage, and which for long voyages commonly amounts to four times the weight of cargo chargeable as freight, and it constitutes the limitation of distance which the ship is able to run under steam at a given speed. This inquiry is therefore essential to a due appreciation of the economic consequences which are involved in progressive variations of steam-ship speed, especially as respects the high rates of speed which are occasionally professed, but which are seldom realised, simply because there has been no recognised exposition whereby such pretensions may be judged of with reference to the required consumption of fuel. In short, regarding this matter as a public cause, affecting as it does the pecuniary interest of the public to the extent of millions sterling per annum, my object is to promulgate, through the medium of the notoriety which every inquiry obtains upon its being brought before the British Association for the Advancement of Science, a mercantile steam-ship Expositor, by reference to which as a standard of comparison the good or bad qualities of steam shipping may be determined; and this surely is a public cause, for by the operation of this scrutiny which such a system of comparative exposition may be expected to inaugurate and popularise, steamers will soon become marketable, with reference in a great measure to their capabilities for economic transport service, according to the speed that may be required; and under the influence of this scrutiny all bad types of form and vicious adaptation of mechanical system will be eradicated; incompetency in steam-ship management will become gradually eliminated, and the mercantile transport service of the country being then performed exclusively by good, well-appointed, and well-managed ships, would be performed at a minimum of cost to the shipping interests, and consequently to the best advantage for the interests of the public.

Digitized by Google

DIAGRAM E.

Showing approximately the Nautical Mileage Consumption of Fuel, for Vessels from 1000 tons displacement up to 25,000 tons, the co-efficients of dynamic performance deduced from the formula $\frac{V^3 D^{\frac{2}{3}}}{\text{ind. h. p.}}$, being assumed to be 250, and the consumption of coals being assumed to be at the rate of $2\frac{1}{2}$ lbs. per ind. h. p. per hour.



Hitherto the dynamic character of steam-ships has been a mechanical problem enveloped in undefined and even delusive terms of shipping and engineering art; consequently its determination has not been based on any recognised principles of calculation. Hence the dynamical character of shipping has been a mystery—a matter of mere assertion on the one hand, and of credulity on the other. But mystery being unveiled, commercial vision will be opened, and competition in shipping, as in any other well understood and open field of public enterprise, will insure the mercantile transport service of the country being performed to the best advantage, and it will gradually establish and preserve the just equilibrium of trade as between the carriers and consumers of all the sea-borne productions of the earth.

The Deep-Sea Pressure Gauge. By HENRY JOHNSON.

The few experiments which I have made on the compressibility of water by pressure show a greater than indicated by Mr. Carston of 1 in 21,740 for the pressure of one atmosphere. The method adopted is that of subjecting to the pressure of a column of mercury a bulb of water on the short end of an inverted glass syphon containing 8 oz. of water, ninety-nine parts in the bulb and one part on the tube, and which is divided into 100 degrees, so that each degree is of the whole $\frac{1}{10100}$ part; and the pressure of each 30 inches of mercury caused a compression of rather more than 1 degree in fresh water, and about $\frac{3}{4}$ of a degree in sea-water. The result varied a little, owing to the effect of slight variations of temperature on the bulb. This difference of result, however, does not affect the principle of the instrument. The compressibility of water is too minute to be recorded in a simple tube, but it may be recorded in two methods: one, with a bulb or bottle and a tube accurately divided, the tube being furnished with an index to be pushed along the tube by a cork or elastic piston isolating the water in the vessel, and travelling along the tube towards the bulb during the descent until the isolated water became equally dense with the water surrounding it; and when pushed back in ascending by the expanding water in the bottle, leaving behind the index to mark the degree of compression, a small aperture at the end of the scale allowing the escape of the air confined by the cork or elastic piston. The instrument to be fastened to a line with the piston downwards, so that the isolated water, being lighter than surrounding water, should press upwards against the top rather than towards the piston. Another method of applying the principle has however been adopted, on the suggestion of Mr. F. Hoffman, who made the instrument; namely, to have a tube or cylinder of metal, and in lieu of a scale tube to use a long bolt of metal, or, in other words, a long solid metal piston, to enter the cylinder through a packing box, and to be pressed into the cylinder by the external pressure of the superincumbent water. In descending, the piston, when pressed into the cylinder until the density of the isolated sea-water equalled that of the sea-water surrounding, it would draw along an external scale an index recording the compression; and on ascending, the piston, when pushed back by the expansion of the isolated water, would leave in its position the index fixed by a spring acting on a toothed rack at the side of the scale. In this form the action of the instrument appears to be very simple—the piston being pressed into the cylinder, or out of it, according to the relative density of the water in the cylinder and of the water surrounding it; and resembles the action of some other hydraulic presses, although this instrument is worked by the pressure of the sea, and others by the hydraulic pump. After a correction for the effect of the friction upon the piston in the packing box, and which is considerable, the instrument appears to record the density or compression of the sea-water surrounding it,—and consequently the pressure to which telegraph lines would be subjected at the same depth.

An experiment of great interest might be made by sending down with this instrument a deep-sea thermometer, and deducting from the total amount of compression the compression resulting from variation of temperature between the temperature of the water at the surface and at extreme depths, and comparing the balance of compression with the depth as indicated by careful soundings, or with some approved instrument, as, for instance, Massey's sounding instrument. Some further experiments will be required to ascertain the effect of variation of temperature on the capacity of the cylinder, and any correction that may be necessary. An endeavour has been made to demonstrate practically the compression of water, by screwing a small cross-bar on to the end of the piston and attaching weights to it; but as the instrument is without the support of the external pressure of the sea-water, which would balance the internal pressure, and has not been strengthened for the present experiment, this experiment must be considered not as an exact one, but simply as an illustration of a principle—the amount of compression being greater than that indicated by the previous experiments.

The vessel is made of cylindrical form, in order to allow some length for the piston and scale, and it contains exactly 10 oz. of water. The piston is of such a size that 26 inches would displace one ounce of water, and is divided into 100 principal degrees,

Digitized by Google

which are subdivided, each principal being one-thousandth part. Of this length a portion of 40 degrees (about 10 inches) has been taken, so that this instrument can record compression up to the extent of forty parts in a thousand. A spanner accompanies the instrument, to unscrew or tighten the packing box when necessary; the other end of the spanner fits into and turns a tap at one end of the cylinder, the interior of which is oval, and the tap has a small air channel to allow the escape of air, so that the cylinder may be filled quite full of water. The instrument may then be placed in the accompanying stand, and the cross bar screwed on to the piston, and weights attached to the cross bar showing pressure after deducting the weight of the two 2-lb weights, together 4 lb., which are required to overcome the friction on the piston in the packing-box when the cylinder is empty. The spring should be relaxed, and the index pressed down a little, and afterwards pushed up to the piston to prevent the friction of the index from affecting the experiment. If the two 5-lb. weights, together 10 lb., are used after deducting the 4 lb. for friction, a pressure weight remains of 6 lb. The diameter of the piston being three-tenths of an inch, the area is about one-fourteenth part of a square inch, and the pressure of the 6 lb. upon the piston is thus equal to a pressure of 84 lb. per square inch.

It is to be hoped that, after some further experiments to ascertain the effect of variation of temperature upon the capacity of the cylinder, and any correction that may be required, the instrument will be found practically useful.

Some Experimental Researches to determine the Density of Steam at all Temperatures. By WILLIAM FAIRBAIRN, F.R.S., and THOMAS TATE, F.R.A.S.

I propose to give a short sketch of an apparatus, and the results of the earlier experiments which, in conjunction with Mr. Thomas Tate, I have been investigating by direct experiments, with the intention of determining the law of the density of steam and other condensable vapours; and thus to solve a hitherto almost untouched problem by an experimental method, which will verify or correct the theoretical speculations in regard to the relation between the specific volume and temperature of steam and other vapours. The experiments are being conducted, it is believed, upon an entirely novel and original principle, and one which is applicable at any temperature and pressure capable of being sustained by glass vessels.

For a perfect gas, the law which regulates the relation between temperature and volume is known as Gay-Lussac's or Dalton's law, and is expressed by the equation,

$$\frac{V \times P}{V_1 \times P_1} = \frac{458 + t_1}{458 + t} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Now density of steam has been determined with accuracy by direct experiment at the temperature of 212°—and at that temperature only—by the method of Dumas. At 212° Fahr. its density is such that its volume is 1670 times that of the water that produced it. Substituting these values of volume, temperature, and pressure, we get for the volume of steam from a unit of water at any other temperature,

$$V = \frac{1670 \times 15}{670} \times \frac{458 + t}{P}$$

Or,

$$V = 37\tfrac{1}{3} \frac{458 + t}{P} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

These are the well-known and received formula from which all the tables of the density of steam have hitherto been deduced, and on which calculations on the duty of steam engines have been founded. Up to the present time, however, this formula has never been verified by direct experiment, nor are the methods hitherto employed in determining the density of gases and vapours applicable in this case, except at the boiling temperature of the liquid at the ordinary atmospheric pressure. But, on the other hand, theoretical speculations throw considerable doubt on the accuracy of the above formula when applied to steam and other condensable vapours. Several years ago Dr. Joule and Prof. William Thomson announced, as the result of applying the new dynamical theory of heat to the law of Carnot, that for temperatures above 212° Fahr. there is a very considerable deviation from the gaseous laws in the case of steam. Later, in 1855, Prof. Macquorn Rankine has given a new theoretical formula for the density of steam, independent of Gay-Lussac's law, and confirmatory of Prof. Thomson's surmise. But as yet these speculations need the evidence and verification of direct experiment.

The density of steam is ascertained by vaporising a known weight of water in a glass globe of known capacity, and noting the exact temperature at which the whole of the water becomes converted into steam. From these three elements, volume, weight and temperature, the specific gravity is known. But in pursuing this method, these two difficulties must be overcome. First, the pressure of the steam renders it necessary that the glass globe should be heated in a strong and consequently opaque vessel. Second, as steam rapidly expands in volume for any increase of temperature beyond the temperature of saturation, it would, in any case, be impossible to decide by the eye the temperature at which the whole of the water became vaporised. The temperature of saturation, or temperature at which the whole of the moisture is converted into steam, whilst no part of the steam is superheated, must be determined with the utmost accuracy, or the results are of no value.

The difficulties thus resolve themselves into finding some other test of sufficient accuracy and delicacy to determine the point of saturation. This has been overcome by what may be termed the saturation gauge; and it is in this that the novelty of the present experiments consists.

To illustrate the principles of the saturation gauge, suppose two globes A and B, connected by a bent tube containing mercury at *ab*, and placed in a bath in which they can be raised

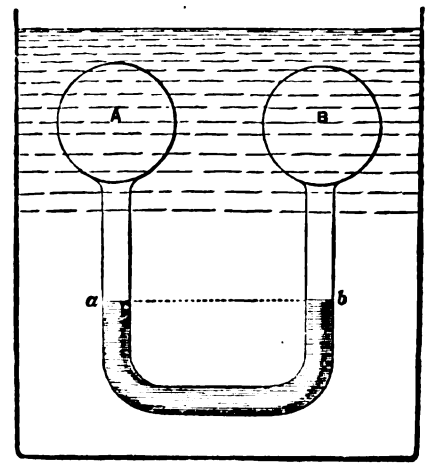


FIG. 1.

to any required temperature. Suppose a torricellian vacuum to have been created in each globe, and 20 grains of water to have been added to *a*, and 30 or 40 grains to B. Now suppose the temperature to be slowly and uniformly raised around these globes; the water in each will go on evaporating at each temperature, being filled with steam of a density corresponding to that temperature, and the density being greater as the temperature increases. At last a point will be reached at which the whole of the water in globe *a* will be converted into steam, and at this point the mercury column will rise at *a* and sink at *b*: this is the saturation test, and the cause of its action will be easily seen. So long as vaporisation went on in both A and B, and the temperature was maintained uniformly, each globe would contain steam of the same pressure, and the columns of mercury, *a* and *b*, would remain at the same level. But so soon as the water in *a* had vaporised and the steam began to superheat, the pressure in *a* would cease to remain uniform with the pressure in B, and the mercury columns would at once fall, and thus indicate the difference. The instantaneous change of the position of the mercury is the indication of the point at which the temperature in the bath corresponds with the saturation point of the steam in *a*.

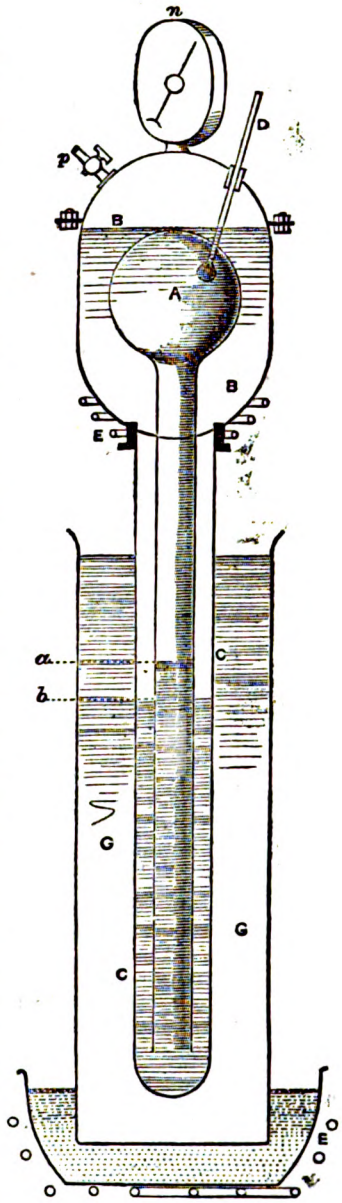
To show the delicacy of this test I may instance, that at 290° Fahr. the mercury column would rise nearly two inches for every degree of temperature above the saturation point, as the increase of pressure arising from vaporisation is twelve times that arising from expansion in superheating at that point, and a similar difference exists at other temperatures.

The apparatus as employed for experiment varies according to the pressure and other circumstances of its use. Fig. 2 represents one of the arrangements, which has been employed with

Digitized by Google

success. It consists of a glass globe of about 70 cubic inches capacity, in which is placed, after a torricellian vacuum has been formed, the weighed globule of water. The globe with the stem is shown at A; this is surrounded by a copper boiler, BB, prolonged by a stout glass tube CC, inclosing the globe stem. This copper boiler forms the water and steam bath through which the globe is heated, and in fact corresponds to the second globe B in the former figure. The fluctuating mercury column, or saturation gauge is placed at the bottom of the tube CC, and the saturation point is indicated by the rise of the inner mercury column A, and the fall at the same time of the outer mercury column B. As soon as the whole of the water in the globe A is evaporated, there is an instantaneous rise of the inner mercury column to restore the balance of pressure, and that progressively with the rise of temperature.

Fig. 2.



As an auxiliary apparatus the boiler is provided with gas jets E, to heat it, and with an open oil bath G, to retain the glass tubes at the same temperature as the boiler, and this oil bath is placed on a sand bath, and also heated with gas. A thermometer D registers the temperature, and a pressure gauge F, the pressure of the steam; and a blow-off cock H serves to reduce the temperature when necessary. A number of results have already been obtained, but they are not yet sufficiently advanced to be made public. The following numbers have been however approximately reduced from the theoretical formula above, and the experimental results may illustrate the use of this method of research. The most convenient way of expressing the density of steam is by stating the number of volumes into which the water of which it is composed has expanded. Thus, one cubic inch of water expands into 1670 cubic inches of steam at 212° Fahr., into 882 cubic inches at 215°, and into 400 cubic inches at 304°, and so on; in this way the following numbers have been computed:—

Temperature.	Volume of steam By formula.	By experiment.
244°	1005	896
245°	969	890
257°	790	651
262°	740	680
268°	680	633
270°	660	604
283°	540	490

These determinations at pressures varying from 10 to 50 lb. above the atmosphere, are not accurate reductions from the experimental results, but only approximations. But they uniformly show a decided deviation from the law for perfect gases, and in the direction anticipated by Prof. Thomson; the density being uniformly greater than that indicated by the formula. I hope by the time of the next meeting of the association, with the assistance of my friend Mr. Tate, to be enabled to lay before the section a series of results which will fully determine the value of superheated steam, and its density and volume as compared with pressure, at all pressures varying from that of the atmosphere to 500 lb. on the square inch.

After the reading of the above paper,

Prof. Macquorn Rankine called the attention of the meeting to the confirmation which the results of those experiments afforded of the mechanical theory of heat. The following formula had first been deduced from the principles of thermodynamics by Prof. Clausius:

$$v - v' = \frac{JL}{t\frac{dp}{dt}}$$

where v' is the volume in cubic feet of 1 lb. of water, at a given temperature; v, the volume in cubic feet of 1 lb. of saturated steam; L, the latent heat of evaporation of 1 lb. of steam, expressed in ordinary units of heat; J, Joule's mechanical equivalent of an unit of heat, whose value for Fahrenheit's scale is 772 foot-pounds; t, the absolute temperature,=temperature on Fahrenheit's scale +461°·2; $\frac{dp}{dt}$, the rate of variation of the pressure of saturated steam with temperature.

Mr. Rankine, in the absence of direct experimental data, had some time ago printed for practical use tables of the density and volume of steam computed by means of this theoretical formula. The following table shows that the results of the formula very nearly agree with those of Messrs. Fairbairn and Tate's experiments.

Temperature. Fah.	Ratio of volume of steam to volume of water. By Theory.	By Experiment.
244	936	896
245	920	890
257	756	751
262	698	684
268	635	633
270	616	604
283	506	490

In the table of comparison between the results of theory and experiment as to the ratio of the volume of steam to that of water, it may be observed that the differences, which range from $\frac{1}{315}$ to $\frac{1}{24}$ of the quantities compared, are all one way, the theoretical results being the larger. It is probable that this may be accounted for by a difference in the value assumed for the density of water. In the theoretical calculation the volume of the steam is compared with the *least possible* volume of an equal weight of water; that is, the volume at 39°·1 Fahr.

Rettie's Patent Submarine Lamp, as Illustrative of the Principle of Ventilation.

The submarine lamp is intended chiefly for using under water, for throwing light upon objects in the beds of rivers or in the depth of the sea: for examining the foundations of piers and bridges, and of the hulls of vessels while afloat, as also for the purpose of attracting fishes and other residents in the deep.

In the construction of the submarine lamp various points had to be attended to as essential to success. 1st. The obtaining of a powerful light by a lamp of limited dimensions and perfectly water-tight. 2nd. Whilst adapted for using near the surface of the water to be at the same time capable of extending with facility, and of sufficient strength to resist the heavy pressure of the water when immersed to any considerable depth. 3rd. The removal of the air vitiated by the flame, and introduction in its place of air capable of supporting combustion.

These different points having been satisfactorily attained, the result has been successful, as in the lamp now shown.

Description.—The lamp may be made either of a globular or cylindrical form (if the former it will require to be of glass), the bottom part being made of copper or brass, with a large screwed opening for the admission of an Argand burner; on the top of the globe is a brass cap, into which is screwed a strong copper tube, in the centre of which is fixed another tube fully one-fourth less in diameter, and so fixed as to allow the air to pass freely between the two: the lower end of the inner tube has a trumpet-shaped termination which enters into the globe, reaching within 2 inches of the glass or chimney of the Argand burner. The

Digitized by Google

upper ends of the tubes terminate in a sort of lantern-shaped top, which is divided into a lower and upper compartment; from the lower compartment in the space between the outer and inner tubes passes the air requisite for the support of combustion, while through the upper compartment is discharged by the centre tube the vitiated air as ejected from the lamp.

The principle on which the lamp is constructed and depends for action is that arising from the discrepancy in the gravity of the two columns of air necessarily engaged, viz., the column of cold and weightier air, and the column of heated or lighter air; and in the arrangement made to foster the respective qualities of the different columns,—thus, the cold air being made to pass through the outer tube is exposed to the favourable action of the water, while the heated and vitiated air passes through the centre tube placed immediately over the powerful burner of the lamp.

After the reading of the paper, the inventor stated verbally that it was not his object to occupy the time of the meeting with the lamp as such, but to induce the attention of engineers and others feeling an interest to the *motive power* elicited in effecting the object there attained, and as affording a striking practical illustration of the principle on which ventilation depends, if not furnishing a key to the more systematic consideration of that subject, which unfortunately for the health and comfort of society is so imperfectly understood; while it appears there is within our reach a principle sufficiently powerful, available alike for ameliorating and moulding the atmosphere of the smallest and largest apartments in which men can congregate; and equally applicable to the removal of the air and gases generated in mines and coal pits unfavourable to the health and safety of the people employed in them.

On an Artesian Well in the New Red Sandstone at the Wolverhampton Waterworks. By J. F. Bateman.

The town of Wolverhampton has been, up to a recent period, supplied with water produced by two deep shafts—one sunk about 300 feet deep into the lower New Red or Permian measures, and the other to a somewhat similar depth in the New Red Sandstone proper. From both of these wells a large quantity of water was anticipated by the engineers who advised their construction, but their yield is under 200,000 gallons a day each, the water being pumped in one case from a depth of above 180 feet, and in the other 246 feet.

The quantity thus yielded being insufficient for the supply of the district, new works have been constructed, which I have just completed, for bringing water from the river Worth at Corford Bridge, about nine miles from Wolverhampton and three from Shifpeak, in the county of Salop.

The works are constructed for the supply of 2,000,000 gallons per day, and the water has to be forced to a height of 500 feet for the supply of the town.

The river Worth, at the place at which the pumping works are constructed, is not more than 40 feet or 50 feet above the Severn, which it joins at Bridgemouth, about eight or ten miles distant. It may, therefore, be considered to be at the bottom of a basin little elevated above the sea. From the character of the surrounding hills and the inclination of the beds of the New Red Sandstone, it appears to me very likely that, although the wells which had previously been sunk on the high plateau of Wolverhampton had proved comparative failures, a considerable quantity of water might be found in the sandstone at Corford Bridge, and that possibly some might rise to the surface, and flow as an artesian well. I therefore obtained the sanction of the directors of the company to sink a bore-hole for the purpose of ascertaining the fact.

In some parts of the country, as in Cheshire and Lancashire, on the shores of the Mersey, the New Red Sandstone is very clearly divided into four distinct portions, consisting of an upper hard mass about 300 feet or 400 feet thick, a soft mass about the same thickness, a second hard mass, and a lower soft mass, all of pretty much the same thickness. In the neighbourhood of Wolverhampton and Shifpeak these distinctions are not so clearly exhibited, but I had reason to believe, from the portion of the works, that a bore-hole of about 200 feet in depth would pierce the hard rock on which they were situated, and reach the soft rock beneath.

The bore-hole was commenced 12 inches in diameter, and continued at that size for 70 feet in depth, when it was diminished to 7 inches, and continued for 190 feet, being a total depth from the surface of 260 feet.

The first water was met with at a depth of 25 ft. 4 in., and from that time it rose to the surface and flowed over an artesian spring, increasing in quantity as the depth increased, till the boring was discontinued, at which time it amounted to about 210,000 gallons per day.

The following table will show the manner in which the water increased:—

Depth below surface. Ft.	in.	Yield in 24 hours. Galls.	Depth below surface. Ft.	in.	Yield in 24 hours. Galls.
25	4	2,880	119	0	37,028
29	4	3,553	123	6	43,200
37	6	3,602	142	4	64,800
45	0	5,400	159	2	74,055
63	3	9,257	169	6	86,400
78	6	18,514	178	11	129,600
86	9	21,600	185	6	130,896
95	0	23,563	211	1	163,200
104	0	25,920	221	7	183,600
111	2	32,400	260	0	209,830

Throughout the whole depth of boring, the rock varied little in character. It was nearly all hard rock; sometimes very hard, with occasional beds of softer stone. For the last 40 feet or so, the soft beds were thicker, but otherwise there was little change from top to bottom.

The greatest increase of water took place at 214 feet and 227 feet in depth, at each of which depths there was an increase of 20,000 gallons per day.

The soft rock I anticipated was not met with at the depth I expected, but sufficient was done to prove the abundance of water. A larger bore-hole, which would permit the descent of a larger column of water, would materially increase the produce as an artesian well, while a shaft sunk 30 feet or 40 feet deep, and exhausted to that depth by pumping, would yield a very considerable quantity. As the whole rock is charged with water to the level of the river, which forms its natural outlet, and as the boring shows that the lower beds receive their supplies from distant sources, the supply to be obtained may reasonably be expected to be inexhaustible, within the limits of that which is due to the percolation of the rain upon the collecting area.

On the Manœuvring of Screw Vessels.

By Admiral Paris, C.B., of the French Navy.

The propelling properties of the paddle and the screw are very different according to the form, mode of acting, and especially the position of the propellers in the ship. A few words will show these differences, and will enable us to deduce the special qualities of each propeller, and thence the method of making a good use of them for the various purposes of navigation.

The paddle acts at the surface of the water, and pushes it in the direction of the keel when working either ahead or astern. The current produced by the resistance of the water is useless to the rudder, because it acts only on the upper part, where it presents no flat surface. It may also be observed, that the action of the paddles will not affect the ship's course unless one is immersed deeper than the other, thus meeting more resistance; or, as in the case of some tugs, when one acts in one direction and the other in the reverse, thus causing the ship to turn.

The screw acts on the water by a twisted surface, which instead of pushing back the water in the direction of the keel, gives it a whirling motion, and projects it abaft in the shape of a cone. The slip produces a current in the same way that the paddles do, but being much below the surface of the water, and just ahead of the rudder, the latter receives the impulse of this artificial current, which acts before the vessel has moved, her inertia causing her for a few minutes to resist the impulsion of the propeller.

Hence a principle is deducible, viz., that a paddle-wheel vessel cannot steer without moving; and that, on the other hand, a screw vessel will steer before moving, and even long after the propeller is at work, if any obstacle resists its transatlantic action. And this difference arises from the action of the screw, because its blades are oblique to the length of the ship, and they are pushing the stern not only ahead or astern, but also sideways, so that if the water were equally resistant close to the surface and below it, the equilibrium of both vertical blades would make the screw act right. But this is not the case; and the water being more resistant as the depth increases, the lower blade moves with more

Digitized by Google

difficulty than the upper one, and the stern being acted upon sideways by this difference in the resistance, the ship will not move right; and if the rudder do not balance this effect, she will deviate always to the same side as observed when going back. This effect will naturally be more or less energetic, according to the immersion of the screw and the relative length of pitch; for if the screw-shaft were at the level of the sea, and the pitch infinite—that is, should the blade be in the plane of the axis—the stern will only be deviated, and not propelled. Consequently, in the actual state of things, the side action of the screw on the stern is a mixture of the propelling and of the lateral effect; this cannot be avoided, and is only lessened by a deep immersion, or the shortness of the pitch, and its direction is according to the side of the thread; thus, a right-handed thread deviates the ship to larboard when going ahead, and to starboard when going astern: it is the reverse for a left-handed thread.

From this it would appear at first sight that the paddle acts much better in making a ship steer well than the screw, and that the disturbances caused by the screw on the true ship's way present obstacles to the management of the ship; but it is not so, and these properties of the screw may be used in such a way as to manœuvre in various ways impossible with paddles. If, for instance, it is desired to turn a vessel short round at the moment before raising anchor, a paddle vessel will want ropes, or at least sails if the wind permits, and her propeller will be used only to resist the wind, or to act in the direction of the keel. The screw however enables her to turn round on the same place, even in a calm, for if she moves gently ahead with the anchor still holding on, the screw, by throwing water on the rudder, makes it steer the ship as though she were under weigh; this is well known, many vessels adopting this plan in order to acquire the right direction without moving ahead, and the moment that this is attained, weighing anchor, and going ahead. If she is not at anchor a screw vessel may be made to turn on herself by the help of her own inertia. Thus, let the screw work back, and the ship will begin to turn her head to starboard, and when she has gone half her length, reverse the engine at an increased speed, with the helm a-port. The ship will then move ahead, still turning to the same side; and by repeating the same operation several times, the turn of the whole horizon will be made in much shorter time than would at first be supposed, and the space required to turn in will be dependent on the duration of each operation.

If there is any wind the sails may be used to accelerate the evolution, either by their oblique action on the ship by the aid of the jib or mizensail, or by increasing the speed of the screw, and backing the sails. These manœuvres of screw ships have often been performed, and have enabled them to thread their way amongst crowded shipping in a space which would have been far too confined for a paddle or sailing ship acting without the help of hawsers. Ships are often required to remain in one position without casting anchor; with sails as with paddles there is always leeway, and the ship cannot stand on unless with a beam wind. There is also a difficulty in taking another ship in tow, and as large ships require much time in sending their tow ropes on board, they are generally obliged to drop anchor, and then weigh again when the second is in tow. This is a very long operation, and can easily be avoided by making use of the before-mentioned properties of the screw when the wind is either ahead or astern. Let us suppose, firstly, a vessel is intending to take in tow another lying at anchor. She will sheet and hoist her mizen topsail and gallantsail according to the wind, place herself at a short distance ahead of the other, and work her engine slowly. Thus the back force of the mizen sails would be compensated by the heading one of the propeller, and the ship, acted upon by these two equal and opposite forces will remain motionless, but she will steer as well as if making way, by means of the artificial current before spoken of; and she will change her position or remain exactly motionless and without any deviation of her head, as long as may be required. I have done this several times when ordered to take ships in tow, and remained once more than twenty minutes with scarcely any change of position or direction. This combination of both propelling powers, sails and screw, may also be employed in maintaining the ships with an oblique direction of the wind two or three points, for example, by bracing properly the mizentopsail; but then there is a slight leeway, and if the wind blows in the direction of the beam it is the usual condition of sailing or paddle vessels standing on.

It is very often useful to be able to back a vessel in any direction, and when he can do this a captain dare go anywhere; with a paddle vessel this is possible for short distances, combined with the help of some sails, but with the screw alone it is impossible, owing to the side action above named. So in a calm a screw ship cannot follow by her stern the same way she made by her head, she must have room enough to turn on herself. Again, suppose a vessel is required to remain in the same place with the wind astern. She sheets and hoists her foretopsail, and works her screw back; these two forces can be balanced by the throttle valve, and their propelling action brought into equilibrium; but the screw deviates the vessel to starboard, and this can be avoided by hauling on larboard braces on to the foretopsail, so that not only the pushing action but also the deviating ones are entirely balanced. I have remained at rest by these means several times, and once for an experiment for half an hour; it was on board a frigate 76 metres or 226 feet long; she changed her direction only one point and a half of the compass, and varied in her position only the distance between two ports; with more attention she would have been exactly motionless. If it is wished to make stern way it is very easy to work the ship to accomplish this by ordering the screw to work quicker, at the same time bracing more the foretopsail; thus the latter will not push too much ahead, and will balance better the deviating action of the screw. By this method, on board the same frigate, I went astern at a speed of three knots, and with the deviation of one point in half an hour. The ship was steered as exactly by her foretopsail properly braced as by her rudder when going ahead, the only attention required being to proportionate the work of the screw to the action of the foretopsail, and to back slower when the wind is light.

From these remarks it will be concluded that the screw ship is more handy than the paddle, not only because she steers better, but also because the deviating properties of the propeller are variously and usefully employed. This leads me to anticipate that the Great Eastern will be the most handy vessel afloat, if the properties of the two propellers are usefully employed. In reality, she has in herself a good and constant head wind, which can be used with an admirable exactness; so, if she were wanted to turn round on herself, let the paddle turn astern and the screw ahead, the equilibrium of these two forces will be soon obtained by ordering a quicker or slower motion to either of the propellers. The artificial current against the surface of the rudder will be thus obtained without any motion of the ship, and she will turn herself very easily. The motion will be accelerated at pleasure by working the propellers with more or less energy, but always equally, which is easily obtained by looking at some point on shore, or the water alongside, and shutting properly the throttle valves. But that is not all, she will steer even when making way astern, which would be impossible in any other vessel unless with a good breeze acting on the topsail; for, suppose the power of the screw to be overcome by that of the paddles, the ship will go astern, but still preserve the artificial current necessary to steer, and it will be a matter for experiment to know the proportion of the maximum of back speed at which the ship will steer, that is to say, the minimum of screw power to be employed in proportion to the paddle. This being known by experiment, the Great Eastern would go up the Thames to her moorings sternways, and steering as steadily as head first. Should the latter be preferred, the properties of the united propellers will still be useful; thus, if it is wished to keep her steering short without making much way, the paddles would be backed sufficiently to balance the screw and keep the ship at 2 knots or 3 knots, or less if wanted, whilst the screw is turning so as to give a speed of 10 or 12 knots, and so that the helm will have an energy unknown on board any other ship, and would not be subject to the influence of tides or currents; and the Great Eastern would go to her moorings by her head or by her stern with greater facility and security than many ships of common dimensions but moved by a single propeller.

Being a seaman, my thoughts were naturally directed to the method of making good use of the means put into the hands of a captain by the skill of the engineers who invented and made the various engines. So, from one trial to another, and reflecting on the principle of the action of the screw, I arrived at a new theory on the manœuvres of these kinds of ships; and to illustrate the difference of their management from that of paddle vessels, I have arranged in two columns in my catechism for seamen and steam engineers the answers to questions on this subject, which greatly facilitates the comparison—the left column for paddles and the right for the screw. A chapter of 100 octavo

Digitized by Google

pages has been devoted to the elaborating the details of these practical means of managing screw ships as easily as a horse, and to expose in a clear manner the variety of methods employed with each propeller to make any manœuvre requisite in intricate navigation, and especially on leaving or entering crowded harbours. I should have been glad to see this method experimented on, or to have used them myself, if permitted, on board the Great Eastern —as this ship is the most interesting problem of modern navigation, and one which involves not only the speed, distance, and economy of transport, but also the means of manœuvring with facility and security this tremendous body, the largest ever created by man to be moved on the sea.

On a Safety Cage for Miners. By ROBERT AYTOUN.

The object of the present invention is to save the lives of miners who may happen to be in the cage at a time when the rope to which it is attached gives way.

It fortunately happens that almost every shaft is provided with a pair of strong wooden rods, called guide-rods, which extend from top to bottom. These are placed on opposite sides of the shaft, with the cage between them. The latter is furnished with iron shoes or slides at top and bottom, which loosely embrace the guide-rods, and constrain it to keep one path in ascending and descending. To cause the cage, on the failure of the winding tackle, to cling to these guide-rods is the object sought in all safety cages.

My plan for effecting this is a mere adaptation of an instrument well known to miners—the key or wrench used for raising and lowering the boring-rods. This little instrument has never been known to lose its hold. It supports 100 fathoms of rods with the same tenacity that it does ten. Indeed, the greater the weight it is required to hold, the firmer is the gripe. It therefore is admirably calculated to support the cage, which, in addition to its own weight and load, may have to bear the weight of some hundred fathoms of rope precipitated on it from above. To adapt this instrument to the cage, a slight modification of the upper shoes and slides is all that is necessary. These shoes or slides are, as usual, two in number, and placed on the opposite sides of the cage and in opposite directions. Each of them has a single bolt or stud, by which it is attached to the cage, and around which it turns; a long arm, to the extremity of which the winding chain is attached; a stop, which prevents the arm from being pulled above the horizontal line; and a spring, which lowers it when the winding chain is slack.

From this description it is easily seen that in the event of the rope or gearing giving way, the springs so tilt the shoes or slides that they immediately seize hold of the guide-rods, in the same manner as the boring-key in the hands of a miner lays hold of the boring-rods, and with the same tenacity of gripe; and although the rope should come down on the top of the cage, the only effect would be to cause the shoes to dig deeper into the guide-rods, and thus to make the hold more secure.

Description of Glasgow Waterworks: Supply of Water from Loch Katrine. By JOHN FREDERIC BATEMAN, C.E., F.G.S.

The Loch Katrine Aqueduct for the supply of the city of Glasgow with water is one of the largest works of the kind which has ever been constructed in this or any other country, either in ancient or modern times.

The act for the construction of this work was obtained by the municipal authorities, after much careful investigation into the best mode of improving the supply of water to the city, in the year 1855, and the works were commenced in the following spring. The money for defraying the cost is borrowed on security of an unlimited rate upon the houses and property within the city.

The undertaking is specially distinguished by the great extent and beauty of the Highland lakes from which the water is brought, —the excessive purity of the water,—the difficult and rugged character of the mountainous country through which the works for its conveyance have been constructed,—and the large volume of water, no less than 50,000,000 gallons per day, which will be obtained for the supply of the city.

The lakes appropriated to the purposes of the waterworks for the use of the city, and for the supply of the millowners, fisheries, and other interests on the rivers from which the water will be abstracted, are Loch Katrine, 8 or 9 miles in length, with a surface of 3000 acres; Loch Venechar, 4 miles in length, with an area of 900 acres; and Loch Drunkie, with an area of about 150 acres: having altogether a water surface of upwards of 4000 acres, and containing within the limits to which they may be raised or lowered about 1,600,000,000 cubic feet of water.

The drainage area of Loch Katrine is 22,800 acres, and of Loch Venechar and Loch Drunkie 23,000 acres, making a total of 45,800 acres. On this the average fall of rain is between 70 and 80 inches per annum. That which falls on the collecting ground of Loch Katrine is about 80 inches on the average of five years' observations. If all the water which flows from the rugged mountain sides into Loch Katrine were impounded, it would afford a regular daily supply of 80 or 90 millions of gallons. The storage which is provided by the works which have been executed is equal to 50,000,000 gallons per day for 120 days without rain. It is obtained by raising the water by proper masonry and sluice-gates at the outlet 4 feet above the ordinary summer level, and by drawing it down, if necessary, to 3 feet below that level, giving 7 feet in depth in all. In like manner, the requisite storage for compensation to the river Teith, which consists of a regular guaranteed quantity per day, is obtained by raising Loch Venechar 5 ft. 8 in. above its ordinary summer level, and drawing it down 6 feet, giving 11 ft. 8 in. in all; and by raising Loch Drunkie 20 feet.

The works at the outlets of the lakes are interesting and important works, at Loch Venechar especially. Provision is made for the discharge of floods as well as for the daily regulated supply, and for securing the passage of salmon and other fish by properly constructed "salmon ladders."

Loch Katrine is 360 feet above the tide at Glasgow, an elevation which allows for the loss of fall in the conveyance of the water, and still secures a pressure of 70 or 80 feet above the highest summit of land within the city.

The aqueduct from Loch Katrine to the city is about 34 miles in length, 10 or 11 of which consist of ridges of rock of the hardest description, forming the spurs of Ben Lomond, which towers to 3000 feet above the level of the works.

Through these ridges, in a tolerably straight direction, the aqueduct is carried principally by tunnelling, the tunnels being 8 feet in diameter, and having a fall of 10 inches in the mile. Across three deep and wide valleys the water is conveyed by cast-iron pipes, 4 feet in diameter, with a fall of 5 feet per mile; and at a distance of about 26 miles from Loch Katrine, near Mugdock-castle, a large reservoir of about 70 acres in extent, and containing 500,000,000 gallons of water, has been constructed. From this reservoir, the top water of which is 311 feet above the sea, the water is taken to the city by two lines of cast-iron pipes, each 3 feet in diameter, one being about 7 and the other 8 miles in length. Of the 26 miles which lie between Loch Katrine and the service reservoir, 13 miles are tunnelling, 3¾ miles are iron piping, and the remainder, where the ground has been cut open, is an arched aqueduct of 8 feet in diameter, having the same inclination as the tunnels. Where the ground has been excavated it is filled in again over the aqueduct, which is covered throughout, and the surface restored to its original condition.

There are in the whole work 70 distinct tunnels, upon which 44 vertical shafts have been sunk for facilitating and expediting the completion of the work. The first tunnel commences immediately upon the aqueduct leaving Loch Katrine: it is 2325 yards in length, 600 feet below the summit of the hill, and has been worked, in addition to the open ends, by twelve shafts, five of which are nearly 500 feet deep. This tunnel is in gneiss and mica slate. The last tunnel is at the southern extremity of the aqueduct, just before it enters the service reservoir: it is 2650 yards in length, almost wholly through whinstone, at a depth of 250 feet below the summit of the hill. Besides these, which are the two longest tunnels, there are at intermediate places others of 700, 800, 1100, and 1400 yards in length.

The rock tunnelled through was in most parts of the most obdurate description. For several miles along the side of Loch Chon, where the work passed through a succession of ridges of mica slate largely mixed with quartz veins, the progress did not exceed 3 lineal yards in a month, although the work was carried on day and night. In the Loch Katrine tunnel, and generally in the mica slate, the ordinary average progress was about 5 yards in a month. In drilling the holes for blasting the rock with gunpowder, a fresh drill or chisel was required for every inch in depth upon the average. About sixty drills were constantly in use at each face, and the cost of gunpowder alone was from 27*s*.

Digitized by Google

to 30*s.* per lineal yard. The character of the rock however (as had been clearly foreseen when the work was determined upon) was such that no water occurred in any of the tunnels or workings so long as they were in the mica slate and clay slate, and there was therefore none of the inconvenience, delay, and cost from the presence of water which usually attend extensive tunnelling. When the works left the slate rocks and entered the old red sandstone, tunnelling was avoided as much as possible, from fear of water; but even in this formation it was met with in much less quantity than had been anticipated.

Not to speak of smaller constructions, there are 25 important iron and masonry aqueducts over rivers and ravines, some 60 and 80 feet in height, with arches of 30 feet, 50 and 90 feet in span; and in addition to about 46 miles of new pipes within the city for distributing the water to the inhabitants, there are about 20 miles of large cast-iron pipes of 3 feet, 3 ft. 6 in. and 4 feet in diameter for conveying the water to the city.

The number of people employed, exclusive of ironfounders and mechanics, has generally been about 3000; and for the greater part of these huts and roads and all other accommodation had to be provided,—the country for the most part being of the wildest and most inaccessible description.

The accuracy with which the works have been executed is most creditable to the resident engineers and inspectors. The difference between the levels taken for parliamentary purposes and those subsequently taken when the works were set out for construction, was only 1-50th part of a foot, or about ½ of an inch in the 26 miles between Loch Katrine and the Mugdock reservoir; and so truly have the tunnels been driven, that the junctions can only be distinguished by the different directions of the drill holes.

The works will be completed for the conveyance of water to the city within 3½ years of the time they were first commenced, and within the time originally contemplated, and at a total engineering cost of about £630,000, being about 10 per cent. beyond the parliamentary estimate, after allowing for some additional works.

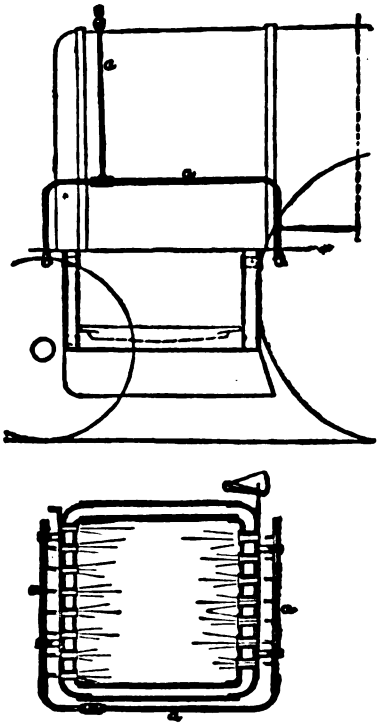
D. K. Clarke's System of Coal-burning without Smoke, by the Method of Steam-Inducted Air-Currents. By Daniel Kinnear Clarke.

The substitution of coal, as fuel, for coke, in locomotives, is not only felt to be a commercial necessity for the reduction of expenditure, but is also discovered to be perfectly practicable as a mechanical problem in conformity with the conditions laid down by the railway acts of parliament that railway engines shall consume their own smoke. The means of doing so, to be adaptable to a locomotive engine, must be simple in design, facile of application to existing locomotive stock, easy to manage, easy to maintain, efficient in promoting the combustion of coal without smoke, keeping up the steam, and saving expense.

These desirable qualifications the writer believes belong to this system of smoke prevention. The whole apparatus is external to the fire-box, and therefore not exposed to heat; and it is controlled in the most perfect manner by a single stop-cock. Air is admitted above the fuel by one or more rows of tubes inserted through the walls of the fire-box, and jets of steam are projected through the air tubes from nozzles one-sixteenth inch diameter in small steam pipes placed outside the fire-box, to increase the quantity and force of the air admitted above the fuel in order to consume the smoke. The jets of steam are used principally when the engine is standing, with the aid of a light draught from the ring-jet in the chimney, to carry off the products of combustion, and they may be shut off when not required. The supply of air through the tube may also be regulated by dampers. The grate-bars are placed close together, with narrow air-spaces, and the ash pan and damper are lightly fitted. The level of the fuel should at all times be below the air-tubes. The annexed woodcut illustrates the application of the system to an ordinary locomotive boiler; *aa* is the steam pipe, branched fore and aft to carry the steam to the nozzles at the air openings, as in the plan, and having a stop-cock next the boiler.

This system is working with entire success on the engines of the Great North of Scotland Railway, at Aberdeen. It is also successfully at work daily (amongst other lines) on several of the engines of the North London Railway, where, as a metropolitan line, the regulations against smoke nuisance are rigidly enforced. It requires a less weight of coal than the engines formerly required of coke for the same duty; and thus saves more than the whole difference in the price of the two fuels.

The locomotive engine has been variously cut up and mangled in order to suit the views of designers for the combustion of coal without smoke. In the plan before the meeting, the original



type of engine promulgated by Mr. Stephenson, and at this day universally adopted and unsurpassed, is preserved intact; and the locomotive is thus rendered a complete and perfect machine, and entirely meets the great railway necessity of the day—the perfect combustion of coal in railway engines.

[Some of the members of the committee, through the kindness of Mr. Cowan, the locomotive superintendent of the Great North of Scotland Railway, had an opportunity of witnessing Mr. Clarke's system in action. The result of the trip was very successful. The smoke was most effectually got rid of, and the apparatus was under such control that smoke was got rid of, or produced, by simply opening or shutting the valves. Mr. Cowan stated that he had had the apparatus working for some time, and could testify, not only to its efficiency, but to the saving in fuel effected by its use.]

Abstract of a Paper on Meteorology. By Admiral Fitzroy.

The barometer is useful not only for the purposes of a "weather-glass," but as a scientific instrument, and for measuring heights. To show the little reliance that can be placed upon the "boiling-point thermometer" as compared with the barometer, for measuring great heights, I mention it particularly, because within the last few years much stress has been laid upon the measurement of some very remarkable mountains by boiling water. Each degree of the thermometer is equivalent to about 550 feet of ascent, or one-tenth to 55 feet; therefore, the smallest error in the graduation of the thermometer itself will affect the height deduced materially.

From inquiries made, I believe that the determination of the boiling-point of ordinary thermometers has been very vague, not only from the extreme difficulties of the process itself, (which are well known to opticians,) but from the radical errors of not allowing for the pressure of the atmosphere at the time of graduation—which may be much, even an inch higher or lower than the mean, or any given height—while the elevation of the place above the level of the sea is also unnoticed. Then there is another source of error, a minor one perhaps: the inner limit, the 180° point, is fixed only by comparison with another thermometer; it may be right or it may be very much out, as may be the intermediate divisions, for the difficulty of ascertaining degree by degree is very great; and it must be

Digitized by Google

remembered that the measurement of a very high mountain depends upon those inner degrees from 200° down to 180° and thereabouts. Hence the difficulty of making a reliable observation by boiling water may be greater than has been generally admitted.

By one of the boiling-point thermometers to which I referred, may be seen at once how very small the degrees in the small space ranging from 180° to 212° must be, while even their starting point is not reliably fixed.

There is an application of the thermometer which might be used more frequently with advantage. I mean the moistened or wet bulb thermometer, used with a dry one, as a "Mason's" hygrometer. One thermometer being moistened, is kept cool by evaporation, and shows its temperature. The two thermometers need not be placed quite together. You may hang either in one place and the other pretty near it, but not close, provided that they are under the same conditions, or in similar circumstances. The bulb of one should be kept moist (not wet, but simply moist), so that evaporation may go on, and then that thermometer will show the temperature at which water is taken up and converted into invisible vapour; while the other will show the temperature of the air. The difference between the two, doubled and taken from the lower, shows very nearly the "dew-point," or that at which dew is formed (as on a bottle of water brought out of a cold place, when, according to the lower temperature of the water within, the deposition will take place sooner or later, by the vapour in the air beginning to be condensed into moisture). Hence you may know whether the air is more or less moist, whether rain is likely to fall or not, or whether your room is too dry or too moist. The water used for moistening the bulb should have acquired the temperature of the air. It is a very simple instrument, and if more freely used, might become very much more popular. In connection with the barometer, it affords an almost unfailing notice of the weather that is coming on.

The Kew marine barometers, which are now much used, are made of glass, iron, and brass. The old barometers used to be generally cased in wood, and had wooden cisterns with leather bags. It is supposed that a metal barometer, with a glass tube securely fixed in it, can be graduated with greater accuracy, and is more reliable in its indications than a glass tube in a wooden case. The French, however, have been hitherto of a different opinion, and use the wooden case still. The English opinion has been, that wood being hygrometric, alters its length, and therefore the graduations are liable to be incorrect. That is one disputed point. Then the method of securing the tube in the cistern is said to be more manageable in wood. The English opticians, however, say that it cannot be well and permanently fixed in wood, because climate, moisture, heat, and cold alter the casing, the cistern, and the leather, so much, that the instrument becomes deteriorated, and lets in air, while the position of the tube is more or less altered. In an iron cistern the tube is securely fixed, so that it cannot vary upwards or downwards. Some think it is too securely fixed, and therefore liable to be broken by concussion more readily than that of an inferior instrument. This, however, appears to be a necessary consequence of greater exactness, and if exactness is requisite the tube must be fixed securely. After the instrument has been graduated and thoroughly verified by the proper process, there are no corrections to be applied to it except one constant, for scale or index error, and one varying, for temperature. None of the corrections depending upon the size of the tube and the relative size of the cistern, and for capillarity, which are necessary in some land standard barometers, are required in these, which, after being verified in a reliable observatory, such as that at Kew (established by the British Association for the Advancement of Science), become valuable as standards.

One difference between such a barometer and an instrument intended solely for use on land is that the upper part only of the tube is carefully measured (or calibrated). Upon the nicety of that part of the tube the value of the instrument chiefly depends; the size of the other part is of little moment, for whether the interior bore is greater or less, makes very little sensible difference to a barometer made upon the Kew principle. Whatever constant errors exist are proved by actual trial, and allowed for. The part of the tube contracted to prevent the mercury from "pumping" (or oscillating with the motion of the ship) may be 2 or 3 inches long. In most of the old marine barometers, the contracted part extends the whole length. Below this there is a "pipette," or a little funnel with the point downwards within the tube. The air which may work its way in never goes *through* the mercury; it always passes between the mercury and the glass: so, by having this funnel within or near the top of the tube, any air which goes up by the side is stopped at the shoulder and there remains; the mercury itself working up and down through the middle of the funnel. After a barometer has been some time in use, if any air has got into this part of the tube (and it cannot get beyond, or into the upper part, when it is thus constructed), or when there is reason to suppose that air has got into this part, you have only to turn the lower end of the tube upwards and tap it gently, when all the air will gradually go out and pass into the cistern again, the barometer tube thus becoming freed from it.

During four years that the office* has been established in which I am employed, such instruments have been sent out and returned from voyages, on board merchant ships as well as men-of-war, sometimes for two or three voyages successively, and most of them without injury. In the first two years several were broken; but chiefly, I may say, through unduly rough usage, several being from the near concussion of guns on board men-of-war. In one instance the barometer was hung immediately under a heavy pivot-gun, which was fired just over it, when, of course, such an instrument could not stand the shock. Others were placed between decks, where men in exercising ran against them, and it thus happened that many were broken during the first two years. During the last two years however there have been very few breakages: not 5 per cent. of the whole number afloat, out of several hundreds that have been supplied, have been broken; so that as far as experience has gone they have stood common work very well. They have been sent by railroad, in a manner which the old barometers could not have borne, and have preserved their merits. Not only is the cistern itself a fixture, as it were, requiring no opening and no adjusting, but the little funnel within the tube prevents air from getting into the part of the tube upon which accuracy depends. I have had the testimony of many authorities, in addition to that of the Astronomer Royal for Scotland, that these barometers are equal to any work for which standards are required on land or at sea.

Still, I think another kind of barometer might be found better for men-of-war with reference to the concussion of guns,—that it might be made upon the syphon principle, and graduated on the glass itself.

The tube of a Gay-Lussac mountain barometer is on the syphon principle; there being no air in the long tube, the mercury falls to a certain distance when the short tube, which corresponds to a cistern, is open. When this short tube or leg is opened, the mercury rises to a certain point according to the atmospheric pressure, just as in the cistern and column mercury acts in other barometers. The scales slide, and you measure from the level of the mercury in the long tube to that of the mercury in the other, so that all errors, excepting those caused by temperature or a defective graduation of the scale, are obviated. It is the simplest of all barometers in principle, but difficult to deal with at present, because the mechanical construction is critical. (It is rather curious that these instruments, perhaps the best mountain barometers of the present day, are now made in England by a person who is employed by the principal opticians, while he is ostensibly keeping a hotel not many miles from London.)

These Gay-Lussac barometers have been taken to many parts of the world, and have been found to answer exceedingly well when duly cared for. Some, however, say they are too brittle, and cannot easily be carried by travellers.

My principal object in referring to them was to show that I thought a barometer upon nearly such a principle, with a very strong and graduated tube, might be made available for men-of-war, which require a barometer far stronger and less brittle than any of the instruments that are now in use. When Sir John Richardson went on his land journey to the Arctic regions, he wished to take a barometer that would bear rough usage in travelling, and he had one made on his own plan. It went with him, and came back uninjured. He had some spare tubes. It was very strong, and would not run any risk unless hit very hard. It was graduated upon the tube itself, which was an eighth of an inch in thickness, to stand rough usage. The tube had an iron screw securely fixed upon it, to go into the cistern. The cistern could be carried in one place and the tube in another; the tube being in a wooden case by itself, and therefore not

* Board of Trade, Meteorological Department.

Digitized by Google

liable to be broken by having the weight of any mercury in it. I do not say that a barometer thus roughly constructed (with *unboiled* mercury) can be compared with the accuracy of a more scientifically constructed instrument, such as our first opticians would make; but I believe that it would be very much more reliable for travellers, within certain limits of error, than boiling-water thermometers, or Gay-Lussac barometers, or any other means that we have at present, because it is strong, it is very portable, the limits of error are known, and they are not too great for use. I believe that one could get the actual pressure of the atmosphere anywhere within *two tenths of an inch;* which, when measuring a mountain from 12,000 to 20,000 feet in height, would correspond to but a small quantity, namely about 200 feet of altitude, a difference much less than the uncertainty of corrections necessary for temperature and other circumstances at a great elevation.

Various anemometers, wind-gauges, or wind-measurers, have been brought into use lately; and within the last few months two such instruments, on the most approved principles, have been sent out to Halifax and Bermuda by the government. It was found by Dr. Robinson (of Armagh) that the shape of a hemispherical cup (exactly the half of a sphere) offered a third greater proportion of resistance to the wind on the concave side than on the convex, and that the velocity of such cups, when put in motion by the wind, is one-third that of the wind, nearly; the wind exerting a third greater force upon the hollow side than it does upon the convex side.* This fact being known, the measurement of the velocity and force of the wind is comparatively easy. The proportion is not quite exactly three to one, but nearly so. Such an instrument may have a self-registering apparatus with clockwork or dials, like those of a gas meter, to register the velocity of the wind in a certain time; the force may be ascertained by comparison with a pressure-plate, or by calculation. The instruments that are sent out to Halifax and Bermuda upon the same principle are large and self-registering. There is an apparatus attached to them of wheels and rollers, with paper fixed on the rollers, so that in whatever way these cups move their indications are registered by the machinery below, connected with clockwork moving a cylinder covered with paper, and a pencil making the indications. All is so well contrived, that it is only necessary to look at and change the paper once a day (Osler's and Robinson's principles combined).

An attempt has been made to obtain a hand instrument, which is much wanted. At present the measurements of wind on board a ship are merely estimated. Lind's wind-gauge, modified by Sir William Snow Harris, and altered subsequently, may yet effect the object in view, which is to get an instrument that you can hold up to the wind. A level which it has shows when it is exactly horizontal; and the means of opening while holding it to the wind, and shutting it instantly at pleasure, are effected by a touch. It is Lind's wind-gauge, with the means of opening and shutting the orifices. The wind blows in, pressing the fluid to a certain distance along the graduated tube according to its strength; your thumb at the back keeps the instrument open till you choose to shut it, when you may read off. It is not perfect, but I believe it will be a tolerable approximation to a wind-measurer. The late Sir Francis Beaufort was exceedingly anxious for some instrument of this kind. His scale, a very good one for merely *estimating* the force of the wind, became generally adopted, not only in this country but in America and France, yet he wanted something of this kind to verify and use with it. I do not say that the gauge described will quite answer our purpose, but it may give means of approximate actual measurement, instead of merely arbitrary estimation.

I would advert to the excellence of the aneroid as a *weather-glass*, if well made. Compensation for heat or cold has lately been introduced by efficient mechanism. In its improved condition, when the cost may be about £5, it is fit for measuring heights as far as 5000 feet with approximate accuracy; but even at the price of £3, as a *weather*-glass only, it is exceedingly valuable, because it can be carried anywhere; and, if now and then compared with a good barometer, it may be relied on thoroughly. There is a screw at the back, which may require to be touched occasionally, to reset the instrument, if out of adjustment. I have had one in constant use for ten years, and it appears to be as good now as at first. For a ship of war, (considering the concussion by the fire of guns,) for use in boats, or to put in a drawer, or on a table, I believe there is nothing better than it for use as a common "weather-glass."

It has been observed that the dryness or moisture of the air should be noticed in connection with foretelling weather; "for ascertaining which, the readiest and surest method is the comparison of two thermometers, one being dry, and the other *just* moistened, and kept so. Cooled by evaporation as much as the state of the air admits, the wet or rather the moist bulb thermometer shows a lower temperature, nearly equal to that of the other when the atmosphere is extremely damp or moist, but lower at other times, in proportion to the dryness of the air and consequent evaporation, even to a difference of twelve or fifteen degrees in this climate during the heat of summer, and twenty degrees or more elsewhere." I have heard of 25° difference in Australia, and parts of Africa, between two such thermometers. From three to seven or eight is usual in England, and six or seven is considered a healthy difference for rooms in which people are living. The two thermometers need not be connected by one frame; but they should be suspended near each other, and in similar circumstances as to shade and exposure, whether to air or radiation of heat from any substance within a short distance.

It is intended in the course of the next twelve months to endeavour to obtain simultaneous observations of wind, weather, and other meteorological information, over the whole Atlantic, and round the coasts of this ocean, by enlisting the aid of observers in every quarter, for one or two observations only in each day; with a view of getting at the exact state of each portion of the atmosphere over our nearest ocean, during one particular time, on certain days, and then mutually comparing those successive and synoptic *views*, as it were, of the atmosphere, in order to discover the usual or normal sequence or succession of winds and weather, as more particularly affecting seamen and agriculturists. A memorandum has been circulated by the Board of Trade, and instruments specially suited have been lately forwarded to Halifax, Bermuda, and other places. The following are extracts from that memorandum:—

"The Royal Society and British Association for the Advancement of Science having made official application to government in favour of the establishment of anemometers at certain selected stations, the meteorological department of the Board of Trade and Admiralty has prepared two such instruments, and arranged for their conveyance to Halifax and Bermuda. It is proposed to request the principal authorities at each place to give aid in placing the anemometer, and arranging for careful attention to it once a day during the limited period of intended investigation of atmospheric laws throughout the Atlantic ocean.

"This period will commence at Midsummer next, and continue uninterruptedly until the following Midsummer. During this interval of twelve months a collection of meteorological information will be sought from every part of the Atlantic Ocean—from ships, and from observers on its coasts and islands.

"It seems only necessary to state the object in view, and how the undertaking originated and is supported, to ensure hearty co-operation."

The scientific questions at issue that will derive so much advantage from the great collection of observations that is now being made in America, France, Holland, and this country, should not be allowed to extend indefinitely, lest the data should grow overwhelming. Up to the present time the practical results, as far as navigation and what one may call "weather wisdom" are concerned, are satisfactory. On board ships, attention to signs of the weather, to winds and currents, and magnetism—and consequent avoidance of accidents, besides saving life, have been remarkable.

On our own coasts there is already in almost every populous fishing village some kind of barometer, and attention is paid to its signs of weather. Fishermen now do not often go out at hazard, but watch the instrument and the sky, and judge for themselves. If results of meteorological investigation can be turned to account even thus practically, besides accumulating as materials for scientific men, those who co-operate in the work may have reason for conscientious satisfaction.

A word may be here added respecting "atmospheric waves" (so-called). Mr. Birt drew particular attention to these supposed undulations of atmosphere, by papers read before the British Association, and by a special article in the Admiralty Manual of Science. Sir John Herschel, Le Verrier, and other great autho-

* The effect of friction is not considered, because, when well mounted and furnished with friction balls (rollers), there is in effect no sensible amount of retardation due to friction.

Digitized by Google

rities have countenanced Mr. Birt's theory, and apparently sanctioned his views. Yet there is so much argument against them, that even the highest names scarcely warrant implicit adoption of those views. That there must be undulations in the atmosphere—constituted as it is—cannot be doubted; but that the curve traced on paper, representing the oscillations of a barometer as the wind veers round the compass, corresponds to a mechanical, wavelike undulation of the body of atmosphere, is not proved.

We may demur to it on these grounds. First, the curve so traced on paper varies not only with the barometer, but with the direction of the wind, which is invariably accompanied by change of pressure, consequent on the greater or less action of polar current.

Secondly, while the wind remains in one quarter, the curve or line, taken as that of a wave, remains almost unvaried, except in consequence of altered strength of wind or much rain, which have each a comparatively small effect.

Thirdly, the lowest part of the curve (called the trough of the wave) always corresponds to the lowest barometer, or *lightest air;* whereas it is the lightest air that rises highest, as instanced at the equator; and therefore the crest of an atmospheric wave (so to speak) ought to be over the place of lowest barometer.

Fourthly, aeronauts always find, and the upper clouds often show, currents above very different from those below. These superposed and successive strata in rapid cross motion must tend to destroy undulation. I am aware of what Sir John Herschel has written on this subject (atmospheric waves) in his invaluable essay on meteorology, in the last edition of the 'Encyclopædia Britannica,' but with the utmost deference I submit that his experiment—on the undulations transmitted through successive (coloured) strata of fluids, *in a vessel*—did not meet the case of fluid strata moving horizontally in various directions across each other.

That there are tidal waves in the atmosphere, caused by the sun and moon, experiment has proved; but that they are very small has also been supposed demonstrated. This subject, however, has yet to be investigated, by means chiefly of the accurate barometrical measures instituted and carried on by government during late years in many parts of the world, and especially at sea. Such waves as these waves would follow their causes, in periodic times,—and not, in utter disregard of sun and moon, only correspond to direction and strength of wind.

On Soluble Silicates, and some of their applications.

By Frederick Ransome.

The writer gave a history of the discovery of soluble silicates, and of the researches and experiments of Dr. Fuchs of Munich, and Prof. Kuhlmann of Lille, and of the several applications of these silicates to stereochromy and various branches of manufacture, and noticed the effects of their combinations with lime, whether carbonate, sulphate, phosphate, or caustic; but described more in detail the value of their application in the manufacture of artificial stone, and in the preservation of natural stone from decay. In the manufacture of artificial stone, he stated that the soluble silicate of soda or potash was mixed with siliceous sand and other similar materials, and after being thoroughly incorporated, the mixture was forced into suitable moulds, and afterwards burnt in a kiln, by which operation the soluble silicate combined with an additional quantity of silica, which was supplied by the sand, &c. with which it was incorporated, and became converted into an insoluble glass, firmly agglutinating all the various particles together into a solid, compact substance, in all respects resembling the finest qualities of natural sandstone. Mr. Ransome produced some specimens of his manufactured stone to the meeting, showing that the material was capable of receiving the most delicate impressions from the most elaborate designs, and that, unlike all other plastic materials which are subjected to a red heat, it retains all its sharpness of outline, and is not liable to contraction or distortion in the process of manufacture. He also gave an account of an interesting series of experiments recently conducted in the testing house of her Majesty's Dockyard at Woolwich, for the purpose of ascertaining the relative properties of his artificial stone, as compared with the natural stones usually employed in the construction of buildings, and showed that its power of resistance to steady transverse strain was represented by 100, whilst that of Darley Dale stone was 81, of Gumshill stone 37, of Portland stone 33, of Aubigny stone 31, of Bath stone 13, of Caen stone 12; at the same time, a block of this material 2 inches cube sustained a weight of 21 tons, whilst a similar block of Darley Dale stone sustained only 16½ tons—thus illustrating its suitability for purposes of construction. In the application of soluble silicates to the preservation of natural stones, the author explained the details of his process, which consists not merely in the application of a soluble silicate, as described and adopted by Prof. Kuhlmann and others on the continent,—and which Mr. Ransome stated he found to be utterly ineffective in this country, being liable to removal by rain, or even by the humidity of the atmosphere,—but consisted first in treating the stone with a solution of silicate of potash or soda, and afterwards with a solution of chloride of calcium, or chloride of magnesia; by which means a double silicate, or silicate of lime, or silicate of magnesia, was immediately formed in the pores and structures of the stone, which double silicate possessed almost indestructible and strongly cohesive properties, enveloping every particle of the stone with which it comes in contact, producing an extraordinary amount of hardness, and hermetically sealing all the pores with an indestructible mineral precipitate, without in the slightest degree destroying the natural characteristics of the stone. Specimens of stones so treated, and samples of the solutions employed, were submitted to the meeting, and Mr. Ransome exhibited an illustration of the principle upon which his process is based, by taking the two solutions, viz., silicate of soda and chloride of calcium, both perfectly clear and nearly colourless, and by mixing them in equal proportions in a glass, a solid substance (silicate of lime) was immediately produced—the chlorine combining with the soda, forming chloride of sodium (common salt), the calcium at the same time combining with the silica, forming silicate of lime. Mr. Ransome stated that the process had now been in operation for nearly three years, and had been eminently successful; that, amongst other places, it had been applied to some buttresses at the new Houses of Parliament, to the Royal Pavilion at Brighton, to the Baptist-chapel in Bloomsbury, and to the Custom-house at Greenock; and that it is now being applied upon Craigendshouse, Paisley, and upon Lennox-castle, near Glasgow. Mr. Ransome also read a professional report he had received from Prof. T. H. Henry, F.R.S., in reference to a series of experiments made by him in order to test the merits of the process, by which it was shown that pieces of Bath and Caen stone when placed in very dilute sulphuric acid were soon deeply corroded all over, and "became entirely broken up, falling into fragments," whereas pieces of the same stones after being treated by this process and placed in the same solution for an equal length of time, were "unacted upon, retaining all their sharpness of outline, having lost nothing in weight."

On the Retardation of Electric Signals through Long Submarine Cables. By Fleeming Jenkin.

(Abstract.)

This paper is not intended by the author to announce any very novel discoveries in the theory of retardation, but simply to detail certain experiments undertaken with a view to obtain confirmation of that theory, to supply certain constants required, and to illustrate clearly the nature of the obstructions to quick speaking through long submarine cables In Messrs. Newall's establishment at Birkenhead great facilities are given for experimenting on considerable lengths of submarine cable, and the author's thanks are due to those gentlemen for the liberality with which they have permitted him to make public the results of experiments undertaken in their interest.

The theory of the submarine telegraph indeed has been well developed by Prof. Thomson, and that theory is confirmed by the results of the experiments to be described; indeed, these experiments have only been rendered possible by the peculiar construction of Prof. Thomson's patent marine galvanometer, which has been the only instrument used in the following investigations.

In this galvanometer a little magnet carrying a small mirror is held by a bundle of unspun silk fibre stretched in a line through its centre of gravity, and powerfully directed by an external hard steel magnet. Light coming from a lamp in front of this mirror is reflected by it and brought to a focus on to a scale at a distance of about 22 inches, and the smallest angular movement of the magnet and mirror, which together weigh only 1½ grain, causes the spot of light to traverse a considerable portion of the scale. The deflection of his magnet is thus indicated with the greatest accuracy, whilst inertia and momentum, inseparable

Digitized by Google

from large magnets, are almost wholly avoided. One consequence of this construction is, that a gradually increasing or decreasing current passing through the galvanometer coils is at each instant indicated at its due strength, no oscillation or vibration occurring beyond that due to the actual changed intensity of the current.

When, therefore, this galvanometer is placed as a receiving instrument at the end of a long submarine cable, the following phenomena are seen. At the moment of completing the circuit through battery, cable and earth, by pressing down the handle of an ordinary Morse sending key, no movement of the spot of light occurs: in a second, or less, according to the length of cable in circuit, the spot begins to traverse the scale slowly, the speed at which it travels soon very much increases, and then again diminishes, until after perhaps a minute a maximum deflection is attained. This movement of the spot is for some portion of the time so gradual, that the interval which elapses between the first depression of the key and the arrival of the spot at various deflections can easily be measured; and these observations thrown into a curve represent very accurately the arrival of an electric current at the end of a long submarine cable.

If, instead of keeping the handle of the sending key pressed down, it is alternately raised and depressed, as in sending dots, the spot of light never reaches the maximum deflection, but oscillates between two points at nearly equal distances respectively from the zero of the scale and the maximum of deflection attainable with the same battery. The distance separating the two points between which the light moves represents the change of intensity in the current at the far end of the cable, and can be easily measured for different speeds of signalling, the dots being sent quite regularly by means of an ordinary metronome. In the same manner, dashes, dots and dashes, successive A's, &c., can be sent with nearly perfect regularity at any speed, and the corresponding changes in the current at the far end of the cable accurately observed and noted down.

The author's first care, however, was to assure himself that the strength of the battery in no way influenced the result. For this purpose the curve of arrival was first taken with 72 pairs of plates on a length of 2168 knots, and secondly with 36 pairs of plates. As might have been expected the two curves could be made perfectly to coincide by simply drawing them to scales proportionate to the strength of the two currents. Thus is once more proved the fact that the speed of electricity is independent of the intensity of the battery, the current always reaching the same fraction of its maximum strength in the same time, whatever that strength may be. It was found that the same curve represented the gradual increase of intensity due to the arrival of a current and the gradual decrease consequent on the ceasing of that current caused by the sending end of the cable being connected with earth.

The curves of arrival for various lengths of from 1000 to more than 2000 knots were then obtained and compared by being reduced to a uniform scale. These curves were found to agree very closely in general appearance with the curves given by Prof. Thomson's theory.* Dots, dashes, alternate dots and dashes, and A's, were also observed for the different length, and drawn in the same manner and to the same scale as the curves of arrival. The discrepancies which they present will, probably, entirely disappear when the theoretical formula including the effects of imperfect and varying insulation is graphically exhibited; as it is not probable that electromagnetic induction produces any very considerable effect. It must here be observed that with the ordinary method of Morse signalling, which will alone be considered in the present paper, the relay is necessarily adjusted to deflect at some one strength of the arriving current; this relay may be so delicate as to deflect to right or to left with the smallest increase or decrease of current beyond this point, but unless that particular intensity be passed by the current no change can take place, and no signal will be received. Let us imagine, therefore, such a relay adjusted to deflect when the current reaches 70, the maximum possible strength of the current being 150: dots sent at such a speed as will cause the current to vary in strength from 60 to 80 will give distinct signals; but if on attempting to send dashes, that is to say, on keeping the circuit closed for twice the length of time required to send dots, the change of intensity varies from 80 to 115, the relay will remain constantly deflected to one side, and no signals whatever will be received. This is distinctly perceived in the curves representing dots and dashes sent at high speeds, drawn or plotted as received on the galvanometer, the successive dashes appearing high up in a quite different part of the scale from that occupied by the dots. It is in this case obvious that no delicacy of relay will enable us to indicate both of these signals at a constant adjustment, nor will any increased strength of battery help us; for, though the variations of intensity are absolutely increased, the relative position of such changes to one another on the scale remains unaltered. In fact the change produced by the use of a more powerful battery is simply represented by plotting the same lines to a larger scale. It might indeed occasionally be desirable to send one signal with great rapidity, and this object might be obtained by the use of extremely powerful batteries and delicate receiving instruments; for since the first appearance of a current at the far end of a cable may be considered almost instantaneous, the actual magnitude of such appearance may on the one hand be increased by the use of powerful currents, whilst on the other hand the use of delicate instruments would permit the earliest and faintest indications of such a contact to be perceived. It is only in the transmission of successive signals that any limiting law of speed can be supposed to exist.

Returning to the consideration of such successive signals, when the speed of transmission is diminished the oscillations increase in size, those for dots and dashes overlap one another, so to speak, and would give legible Morse signals by means of an ordinary relay. This effect is more easily represented by a drawing than described by words.

By the adoption of the means above described the following results were obtained. It was found that whatever the length of the cable the amplitudes of oscillation of the spot representing dashes, or A's, or any other letters, were strictly proportional to the amplitude of oscillation representing dots, and consequently that the speed of signalling possible could be measured by such amplitude as soon as in one case it was determined what speed of dot signalling was compatible with the reception of all other combinations of dots, dashes, and spaces.

The possible speed of signalling was also found very nearly proportional to the squares of the lengths spoken through; the slight departures from this being no more than might possibly be accounted for by taking into consideration the resistance of the battery and galvanometer, and the imperfect insulation of the wire, and also by making allowance for the intervals of time during which the cable is connected neither with earth nor battery, that is to say, when the key is moving between the back and fore contacts.

Thus a speed which gave 15 dots per minute in a length of 2191 nauts reproduced all the effects given by a speed of 30 dots in a length of 1500 nauts; that is, the amplitude and position of oscillations showing dots were precisely similar.

At these speeds, by extremely regular sending perhaps, a relay might give alternate dots, dashes, or dots and dashes, but the introduction of a space between two A's would render the dot of the second invisible.

This conclusion is, however, based on the assumption that in sending dots the key shall only be pressed down for half the time employed in sending dashes; and it is by no means impossible that by a better proportion between lines and dots, not only this but a still higher speed of speaking might be attained.

The author is informed that practically in the Red Sea a speed of from seven to eight words per minute was attained in a length of 750 knots; this would correspond according to the law of squares to a speed of twelve to thirteen dots per minute in a length of 2190 knots. This result agrees very closely with the deduction from his experiments just described, and would appear to show that the influence of electromagnetic induction due to the disposition of the cable in coil does not very materially retard the possible speed of signalling.

It is also found that the amplitude of oscillation representing dots due to various speeds can be thrown into a curve which would be the same for all lengths, the scales of speed being however proportional to the various speeds at which the dot either becomes invisible or bears some other fixed proportion to the maximum deflection that can be produced by the current. Moreover, since the law of retardation does not depend either on the nature or dimensions of the materials composing the wire, although its amount of course much depends on such dimensions, we can by means of the above curve determine from one single observation the amplitude of oscillations attainable at any other speed, and since the speed of signalling depends, as above stated, simply on

* Proceedings of the Royal Society, May 1855. Republished in the 'Philosophical Magazine.'

Digitized by Google

such amplitude, the actual possible speed of signalling can be determined. The amplitude of oscillation required in the dot in order to give distinct signals by any proposed system of speaking having been previously determined by direct experiment.

This amplitude is much modified by the nature of the receiving instruments, by the nature of the signal, by the skill of the manipulator, &c., thus the amplitude required would be lessened and the speed of speaking increased by the use of Thomson's galvanometer as a receiving instrument, instead of the ordinary relay.

The above method of determining the speed of signalling possible with a given cable presupposes that a considerable length shall have been previously manufactured. In default of such condition, the author has no doubt that the proportion of speed of signalling possible in any two cables will, according to Prof. Thomson's theory, be inversely proportional to the square of their respective lengths, to the resistance of a unit of length and to the charge on that unit.

Mechanical senders would materially increase the speed at which signals of any kind could be transmitted. The best trained hand cannot equal the accuracy of mechanism, and the slightest irregularity causes the current to rise and fall quite beyond the limits required for distinct signals.

On examining the curve of arrival given by experiment, the time required to reach any stated fraction of the maximum current was not found to be proportional to the square of the length spoken through, as by theory should have been the case. This discrepancy is supposed at present by the author to be due to the influence of each convolution of the cable upon those surrounding it, giving rise by induction to extra currents, which might cause the proportional retardation in short lengths consisting of three or four large coils to be greater than in longer cables disposed in nine or ten separate coils.

This influence of electromagnetic induction, due to the mutual action between different portions of each coil of cable, on the charge and discharge of the wire, renders all the results obtained from the experiments at Birkenhead liable to correction, and the author hopes either personally to have the opportunity of making similar experiments on a submerged cable, or that this paper may have the effect of inducing others to follow out the inquiry.

Besides the above experiments a comparison was made between signals sent by alternate reverse currents and those sent by alternate contacts with one pole of a battery and with earth. As might be expected, no important difference was perceptible between the signals sent by these two means. One diagram would serve for both sets of signals, by simply drawing a line parallel to the base line of the curve at half the height of the maximum: this line being taken as the base or zero line for the signals sent by reverse currents, all deflections above being called positive, all deflections below this line negative. The only observable distinction between the signals obtained by the two methods was this, that the jagged lines representing dots, dashes, &c., stand rather nearer the maximum when sent by reverse currents than when sent by the simple current. This is caused by the state of equilibrium to which the wire tends to return during the interval between the two contacts being in the one case half way down the scale, in the other at the bottom of the scale. The amplitude of the vibration, and consequently the distinctness of signalling, was quite the same in the two cases

The author, however, having been assured by excellent authority that advantage was derived from the use of Messrs. Siemens and Halske's submarine key on the Red Sea line, and as no correct explanation of why it should be advantageous had been given, the author felt compelled to seek for its superiority in some other cause than that of its transmitting reverse currents. This key has a third contact, by means of which, when signals are not being sent, the sending end of the cable is put to earth instead of being connected with either pole of the battery. A decided advantage is thus obtained, for whereas in the ordinary system the cable has to be charged up to about half the maximum strength of current before intelligible signals are received, by this plan the wire is kept when not in use in that condition in which it is immediately fit for transmitting signals. In other words, the spot of light, should the maximum be 150 divisions on its scale, has by repeated dots with the ordinary key gradually to gain 70 before distinct oscillations or signals, say from 60 to 80, are obtained; whereas by Siemens' key and reverse currents the spot stands at 0, and immediately on dots being sent, oscillates from +10 to −10. Once started there is no difference in the two systems, and the same effect may be produced without the use of reversed currents by keeping half the battery connected with the line when signals are not being sent. This plan would obviously have very great inconveniences, and it is only mentioned to show the nature of the advantage obtained by Siemens' key. No experiments have yet been tried with magneto or induced currents.

It is the author's intention to communicate a paper to the Royal Society giving a detailed account of the experiments alluded to in the present paper, which has been somewhat hastily prepared, owing to the short time which has elapsed between the conclusion of the experiments and the meeting of the association.

ADDITIONS TO THE BRITISH MUSEUM.

A spacious new Gallery has been recently added to the antiquities department of the British Museum, by roofing over one of the small lateral quadrangles. The gallery thus obtained is 95 feet long by 41 feet wide, and has been entirely filled with sculptures from the ruins of Assyria. These curious sculptures will form (with those previously deposited in the Museum) the complete collection of examples of Assyrian art, found within the mound of Kouyunjik and adjacent localities by Layard, H. Kassam (the Arab), and Mr. Loftus.

The new gallery is arranged in three avenues, and the works consisting entirely of bas-relief slabs of alabaster are arranged on the walls and admirably displayed; abundance of light being obtained from the roof. They consist principally of battle scenes, and tiger and lion hunts, and exhibit excellent examples of the sculptor's art at the early period to which they belong. Most of them are in good preservation, arising from their having been buried in the earth and consequently protected from atmospheric action. This gallery will shortly be opened to the public.

Two very handsome drinking fountains have just been fixed under the portico of the principal entrance to the Museum. They are cut from the solid in Sicilian marble, of the semi-tazza shape, simple and appropriate in design. In each case the water flows from a lion's head very effectively carved from a model by Mr. Sykes, formerly a pupil at the government school of design. The fountains will be supplied with water filtered by Ransome's process. They form a striking contrast to most of the vulgar common-place erections called fountains, composed of a medley of iron, stone and compo, lately fixed in numerous localities, to the disgrace of our metropolis.

Many of our metropolitan readers must have observed within the last twelve months that the colonnades on each side of the grand portico forming the principal entrance to the museum have been temporarily inclosed somewhat rudely with rough glass in wooden frame work.

These two inclosures contain some of the finest specimens of sculptural and architectural art of a peculiar class that the nation possesses, the greater part of which are the original portions in marble that formed the celebrated Mausoleum of Mausolus which was erected by Artemesia, as an affectionate memorial to her husband. For the fragmental remains of this noted tomb we are indebted to Mr. Newton, a gentleman who in 1856, with much difficulty and praiseworthy perseverance, through the influence of Lord Stratford de Redcliffe procured a firman from the Turkish government giving him permission to make excavations in the vicinity of the castle of Budrum, in the hope of finding the foundations and other portions of the Mausoleum. Accordingly, after considerable exertion Mr. Newton, under the patronage of Lord Clarendon, then foreign secretary, induced our government to order excavations to be made on an extensive scale, and further to send out a ship of war, with a body of sappers, an officer of the Royal Engineers, and a competent architect to superintend the required operations.

With these facilities, and guided by the valuable advice of Prof. Donaldson, a great authority on oriental architectural antiquities, and who moreover had examined the precise locality in the city of Cnidus thirty years ago, Mr. Newton's labours were crowned with success, and the results of his indefatigable endeavours are now to be seen (although not yet open to the public) in the temporary inclosures we have mentioned.

As a matter of course, the collection is in a great measure fragmentary, comprising hundreds of pieces, which have however been united with great care and admirable precision by expert workmen. The examples already completed exhibit some of the most exquisite specimens of Greek art, second only, and in some

Digitized by Google

instances equal, to many of the productions of a similar class that were executed during the Phidian age on the Acropolis at Athens.

It would appear that Mr. Newton has been enabled to determine almost with certainty that the dimensions of the Mausoleum were according to the description handed down to us by Pliny; viz., that it was composed of thirty-six Ionic columns ranged round a circumference of 411 feet, and above this was a pyramid of peculiar construction, consisting of twenty-four steps of about 1 foot each. This pyramid was crowned by a magnificent group of sculpture consisting of a colossal statue of Mausolus and accompanying figures in a chariot, 10 feet in height, drawn by four horses. Some doubt exists about the total height of the Mausoleum: it is however supposed to have been, including a large basement of green rag stone on which the columns stood, about 140 feet. But even taking all doubts into consideration, what must have been the effect of such a grand composition! as Mr. Newton justly observes of "this marble mass, decorated with the most magnificent architecture, picked out with colouring, as seen against the blue sky of Caria. It must have been a spectacle such as the world had never seen before or since, and which justified the judgment of the ancients, who called the Mausoleum one of the seven wonders of the world."

Among the remains are portions of the Ionic capitals to which we have referred. They are of most elegant design, and worked with a skill and masterly execution which our modern architectural carvers would do well to study carefully. Other ornamental fragments are equally fine, and combine a minuteness of manipulation and an exquisite refinement of finish that none but first-rate Greek artists have yet attained. The anatomy and draperies of the statues bear a great resemblance to similar works that were produced in the age of Pericles, as seen in the productions of Phidias, Praxiteles, Alcamanes, and their contemporaries. But one of the most distinguished examples is a superb colossal lion, 10 feet in length, and 6 feet in height from the base line to the top of the head, compared with which the four so-called lions in front of St. George's-hall, Liverpool, are insignificant. This *chef-d'œuvre* of the sculptor's art was not found at Halicarnassus. We shall give its description in Mr. Newton's own graphic words.

"Mr. Pullen searched the coast to the south of the town (Cnidus)—and at about an hour's walk he found a great lion lying on a rock, and close to him was a tomb. The lion is 10 feet long, and 6 feet high at the head. The effect of that lion against the eastern sky when he was raised from the ground was the finest he had ever witnessed: he seemed to look at them with an angry glance, as much as to say 'Why do you rouse me from my sleep of 2000 years?'" Mr. Newton adds that "The use of lions in monuments might be traced all through the ancient world; in the Mausoleum they seemed to be used as sentinels. He thought this lion was intended as a watchman or sentinel looking out seaward. As the mariner passed up he would see the Colossus at Rhodes; he would then see this colossal lion; then see the famous city of Cos, and the mausoleum on the opposite side; and then he would pass the temple of Apollo at Branchidæ, and the temple of Ephesus." Such sights however are to be seen only in one part of the world, and that is in the Greek Archipelago.

Concluding this hasty description of what may be termed the Halicarnassian collection at the Museum, we would express an earnest hope that the trustees of the British Museum will instruct their architect, Mr. Sidney Smirke, to prepare a suitable gallery in which to display this beautiful collection of Greek antiquities, which is invaluable were it only for educational purposes to all who are engaged in the architectural and plastic arts.

The New Bowery Theatre, New York.—This theatre has lately been completed: it occupies a site measuring 75 feet on the Bowery, and running back 204 feet to Elizabeth-street, where it has a frontage of 100 feet. The auditorium consists of a pit or "parquette" holding 2,500 persons, and three rows of boxes which will seat 2000 more. The stage is 85 feet deep and 50 feet wide. The scene rooms, dressing rooms, green room, &c., are on either side of the proscenium, leaving the stage perfectly clear for the display of spectacle performances. Next to the Academy of Music this is the largest place of amusement in the city, as it is calculated that 5000 persons may be accommodated within its walls. The cost of the structure was 150,000 dollars. The architect was Mr. J. M. Trimble.

REVIEWS.

A Practical Treatise on the Manufacture and Distribution of Coal Gas; its Introduction and Progressive Improvement. Illustrated by engravings from working drawings, with general estimates. By SAMUEL CLEGG, Jun., M. Inst. C.E., F.G.S. Third edition, enlarged.—London: John Weale.

Gas lighting has become almost a necessity of civilised life—at least of life in towns—therefore a knowledge of the theory and practice of its manufacture is one of the requirements of modern education. Mr. Clegg's treatise on the subject has long been a standard authority, but the many improvements that have been made since the former editions were published had rendered it in some measure obsolete. The volume before us has been prepared with great ability and labour, and its pages prove an intimate acquaintance with this extensive subject on the part of its indefatigable editors. The amount of letterpress is nearly double that contained in the last edition, and numerous valuable additions have been made to the plates. It retains all that is valuable in the former one, and brings down the state of knowledge in the various processes of gas-making and distribution to the present time. It will be found very valuable to all who are interested in gas-lighting, or who wish to acquaint themselves with the nature of its manufacture.

Several of our readers no doubt remember the time when gas light was a curiosity, and some, perchance, may be personally acquainted with the struggles that system of illumination had to encounter, and the prejudices that opposed its introduction. Mr. Clegg, the father of the author of the treatise, was among the first who laboured to introduce gas-lighting, and bring it to perfection, and he now lives to see his labours fully accomplished. Among those whose prejudices he had to encounter was the distinguished chemist, Sir Humphrey Davy, who ridiculed the notion of lighting London with gas, and jeeringly asked Mr. Clegg if he intended to convert the dome of St. Paul's into a gasometer? At the present time the dome of St. Paul's would not be sufficiently capacious to hold one-tenth part of the gas consumed daily in the metropolis.

It was with gas-lighting as it has been with all other great inventions; it had to fight its way against obstacles from every quarter which nothing but the undaunted perseverance of those who undertook to support it could have overcome. The impurity of the gas first made, and the ignorance of some of those who were engaged in its introduction, tended also materially to prevent the public from using the new light. Mr. Winsor, who is described in the volume before us as "an impetuous schemer," published such extravagant representations of the advantages of gas-lighting, and conducted himself with so much quackery, that all sober-minded people laughed at him and his schemes; and yet it was owing to his persevering efforts that the first gas company was established. The London and Westminster Chartered Gas Company obtained their act of parliament in 1810, and for two years after they commenced operations they fitted up and supplied shops and houses with gas free of expense, for the purpose of removing the fears of the public, and of inducing them to burn gas. So great was the dread of that plan of illumination, that when Westminster-bridge was first lighted with gas, in 1813, the lamplighters refused to work, and for a few nights Mr. Clegg was compelled to light the lamps himself.

The improvements that have been effected in gas-lighting since the establishment of the first public gas company have removed the objections that were at first reasonably entertained against it, but there is still some lingering prejudice to its general adoption, which the following extract may tend to remove:—

"There are thousands who firmly believe that coal-gas in burning gives off some highly deleterious agents, from which wax, tallow, oil, and even coals themselves, are entirely free; and this belief is supposed to possess corroborative testimony in the shape of facts displayed in the creation of disease, or in the misconceived opinions of medical men. Now the real truth of the matter is, that whether gas be burnt under the name of gas or not, can make no difference to the advocates of this strange prejudice, for under all the circumstances used in the ordinary burning of wax, tallow, oil, &c., it is gas, and nothing but gas, that is burnt; the only difference being that coal-gas is always purified before it is consumed, whereas the extemporaneous gas of a candle or lamp is consumed without being purified at all; and hence, light for light, it must and does vitiate the air of an apartment vastly more than coal-gas. If, therefore, it be true that gas is insalubrious, then wax and oil must be decidedly more so, from the simple fact that all the impurities they evolve pass into the atmosphere of the localities lighted, whereas the great bulk at least of those from coal-gas remain at the gas-works. The actual question for the

Digitized by Google

public to consider is, not whether the burning of gas be injurious to health, for in one shape or other gas must be burnt to procure light; but the point is, whether it is better to consume for this purpose gas of a pure or impure quality."

Experiments made with a view to test the relative contamination of the air by the combustion of gas and of other substances used for illumination, prove that the advantages on the side of gas greatly preponderate, even when compared with wax. In one series of experiments, the flame of coal gas, and the flames of other combustibles that gave an equal light, were burned separately in given quantities of atmospheric air, and the times were noted at which the flames were extinguished. It was found that the flame of a tallow candle was extinguished in 75 minutes, of sperm oil in 76 minutes, of a wax candle in 79 minutes, spermaceti in 83 minutes, and coal gas, of the quality usually supplied in London, in 98 minutes. The flame of cannel gas of superior quality was not extinguished in less than 152 minutes.

It is commonly supposed that gas-making is a very simple process, and that it requires little scientific knowledge, but there are, in fact, few manufacturing processes that require more skilful application of chemical and mechanical science than the manufacture and distribution of gas. In the first place it requires judgment in the selection of the coal to be employed, and then nice adjustment and regulation of the retorts to obtain from the distillation of coal the best results, for it is possible so to conduct the process that the gas generated from the same coals may have scarcely any illuminating power. The purification of the gas from the sulphuretted hydrogen, carbonic acid, and ammonia that it contains when it issues from the retorts, is an eminently chemical process, and in the choice of means by which the purification may be best effected under varied circumstances requires great discrimination. Lime was the substance originally used by Mr. Clegg, sen., for extracting the impurities from coal gas, and it is the simplest and most effective substance for the purpose that has yet been discovered, but the intolerable stench of the spent lime, owing to its free liberation of sulphuretted hydrogen, prevents it from being employed in inhabited localities, and the ingenuity of chemists has been exerted to devise some other means of purification that is not open to that objection. Oxide of iron was known to possess the property of abstracting the sulphuretted hydrogen from impure gas, but the cost of that material prevented its general use, until it was discovered that, by mere exposure to air after it had been removed from the purifiers, the oxide is revived, and becomes capable of being used again and again. Patents have been taken out for the use of oxide of iron founded on that discovery, and one of the patentees received an income of at least £6000 per annum by granting licenses to the gas companies to use the oxide of iron process, which is now generally adopted in towns. The construction of large gas-holders for storing the gas ready for distribution, the regulation of the supply by governors, the laying down of mains and the modes of jointing them to prevent leakage, the construction of meters for measuring the gas, and the various forms of burners best adapted for making it yield the greatest amount of light, require much mechanical skill and a knowledge of the laws that regulate the motion of gaseous fluids through pipes. These subjects are considered in detail in this edition of the Treatise on Coal Gas. Nor is the work of the gas engineer finished when the gas has been conducted to the burners, for he has then to measure by delicate photometrical experiments the illuminating power of the gas after it has undergone all the processes of manufacture. The Bunsen photometer is the instrument now generally employed for that purpose, and when carefully managed, with the precautions prescribed, the illuminating power may be estimated with a close approximation to correctness. It has thus been estimated that common coal gas supplied by the metropolitan gas companies gives a light, when burning at the rate of five cubic feet per hour, equal to about thirteen sperm candles; but the cannel gas supplied in Liverpool, Edinburgh, and in most towns in Scotland, possesses double that amount of illuminating power. In some parts of the metropolis cannel gas is now supplied, for which the consumers are charged 6*s.* per thousand feet instead of the usual price of 4*s.* 6*d.* As the better quality of gas however gives nearly double the light, it is much more economical as well as more pure than the gas made from ordinary Newcastle coal; yet the delegates from the metropolitan parishes who are now endeavouring to reform the gas supply of London are discountenancing the superior kind, and desire to have the 13-candle gas established as the standard of illuminating power.

An important part of the business of the gas engineer consists in the treatment of the residual products of distillation, which if skilfully managed may be made to cover the cost of the coal distilled. The coke is the most valuable of the residues, though the porous quality of gas coke renders it unfit for furnace work, and therefore considerably diminishes its value. By some processes of gas-making noticed in this treatise this defect is remedied, and solid coke is produced, but in obtaining that result the illuminating power of the gas is diminished, and it becomes necessary to enrich it by mixture with gas of a superior quality. This production of good furnace coke from gas retorts is a subject of interest to engineers generally, and we shall most probably revert to it on another occasion. Of the other residual products the ammonia is the most valuable. During the distillation of Newcastle coal the quantity of ammonia given off by each ton is equal to the manufacture of about 24 lb. of sulphate of ammonia. Tar also is an abundant product, and the uses to which it is capable of being applied experimentally are almost innumerable, but as the processes of its conversion are somewhat troublesome it has not been practically rendered of much value, and in many gas-works tar is used as fuel to heat the retorts.

In noticing the many uses to which the products of distilled coal may be applied, the editor of the treatise observes: "There is no part of the residual products of the manufacture of coal gas that may not be rendered serviceable, and eventually when applied with all the resources of science they will probably be found to repay the cost of the raw materials employed both in its manufacture and purification." This is an important consideration, for it is by careful management of the different processes to avoid waste that the gas companies have been enabled to reduce their charges to one-third of their former amount, and it is by a continued improvement in the manufacture that gas consumers have principally to rely for further reductions.

Examples of Stained Glass, Fresco Ornament, Marble and Enamel Inlay and Wood Inlay. By J. B. Waring. Drawn on stone and printed in colours by Vincent Brooks.—London: Atchley and Co.

This splendid volume contains forty-one plates of specimens of the arts connected with architecture as executed in central Italy from the thirteenth to the fifteenth century. These consist of eight examples of stained glass, eight of fresco ornament and figures, five of marquetry or wood inlay, fifteen of marble and enamel inlay, two of heraldic sculpture, two of the sides of a superb marble fountain, and one gives a portion of the interior of the cathedral at Siena, showing the beautiful polygonal font in the baptistery in perspective.

The work may be classed in four divisions, viz., stained glass, frescoes, wood marquetry work, and marble and enamel inlay. In the first class we may especially enumerate Plate 3, giving four compartments of painted windows in St. Croce, Florence, the subjects being the twelve apostles and the annunciation. In addition to the figure subjects in these windows, we especially direct the attention of artists in stained glass to their cleverly designed borders. Plate 4 is extremely rich in colours, more particularly in deep blues, ruby, and green. Plate 5 is a splendid figure of St. Paul from the work of Alessandro Fiorentino, executed in 1491. In reference to this specimen we may observe that the statue of the great apostle is surrounded by architectural detail of a somewhat puerile description, which detracts from the dignity of the statue. Plate 8 contains a portion of a window in Arezzo Cathedral, on which are represented niches and architectural details *in perspective;* we think this mode of treatment should be avoided, it being next to an absurdity to attempt the representation of depth and distance on a transparent surface. Some of the examples of fresco ornament are exceedingly rich in colour, and their designs are in endless variety. Plates 10, 12, and 13 are particularly noticeable. Although in Plate 16 there are many beautiful combinations and useful studies of contrasts of colour, we cannot admire the figures under canopies *bent* round the arch, and the filling of the spandrils with representations of buildings which are unsuitable and bad in design. Many of the examples of wood inlay are extremely curious; and some of those in marble and enamel are truly superb—more particularly those

Digitized by Google

illustrated in Plates 22, 24, 29, 30, 31, 34, 35 and 36—severally sketched from the baptistery at Pisa, the baptistery at Florence, the churches of Santa Croce and S. M. Novella, the cathedral at Siena; a pavement by Beccafumi, a portion of the shrine in the church of San Michele, Florence, a compartment of the noted silver shrine of San Giovanni, belonging to the Duomo at Florence, and a panel from the altar of St. James, Pistoia Cathedral. Many of the examples of stained glass are from the works of Dominico Livi da Gambussi, Allessandro Fiorentino, Angelo Lippi, Bernardo di Francisco, Guido Nicolai, Lorenzo di Antonio, and Dominio di Piero; and among the examples in fresco the most prominent are from the productions of Giotto, the Bartolo family who flourished in Siena at the close of the 14th century, Taddeo Gaddi, Simone Memmi, and Spinello Aritino. The descriptive letterpress is copious and highly valuable.

The book is of super-royal folio size, and is got up in a very superior manner. An examination of the work will insure the opinion that Mr. Waring the artist, Mr. Brooks the lithographer, and Mr. Edward Taylor, deserve the thanks of all those who practice architecture, glass painting, and the arts connected with building.

NEW SCHOOLS AND TEACHERS' RESIDENCES, ST. MARY, ISLINGTON.

These buildings were commenced in March last, and are now progressing rapidly towards completion. They occupy a position on the eastern side of Little Cross-street, near the parish church. The frontage on the street contains the teachers' residences in one block, with the entrance passages to the schools on each side; the arrangement being extremely simple and convenient. The school buildings and class-rooms are built upon ground at the rear. The architect has adopted the Domestic Tudor style, which has been very successfully carried out. The external facings of the principal parts of the structure are of white Huntingdon bricks with Bath stone dressings, &c. The roofs are covered with "Duchess" slates.

The arrangement on the ground floor of the schools consists of a room for boys, 56 feet by 30 feet and 18 feet high, and a class-room connected with it, 22 feet by 14 feet and 18 feet high. The desks are arranged on either side of the school room for eight classes of twenty-four children in three rows of eight each, those in the rear being placed on raised stages, and the class-room has a platform also with raised stages capable of accommodating forty-eight children. Access to this school is obtained on the south side of the teachers' residences by an open passage leading to an entrance and cap room, 10 ft. by 6 ft., fitted with rails and hooks. The water-closets, coal store, and stowage room are planned on one side of the playground. On the upper floor there is a room for girls, of similar dimensions to that mentioned for the boys, with a class-room attached, 22 feet by 14 feet and 17 feet high. Access to this school is on the north side of the teachers' residences, in connection with which there is a lobby and stone staircase. This entrance-lobby also gives access to the playground. On the staircase leading to the girls' school a mezzanine floor is combined with a store-room, and above it a cap or bonnet room of the same size for the use of the girls. Large slate cisterns are provided for each school.

The constructive planning of the building as regards strength appears to be very complete. On either side the walls have projecting buttresses at all the points of support for the flooring and joist timbers. The upper floor rests upon five sets of trusses, consisting of binders, queen-posts, collar and struts, supported at each end upon curved brackets springing from stone corbels. The joists which are laid upon the binders are block-strutted throughout, and the great width of flooring thus rendered perfectly rigid and free from vibration. The constructive timbers are seen below the ceiling in the boys' room, and with the wall linings round the lower part of the school, which are of deal, are stained and varnished. The main timbers of the roof consist of five sets of principals with curved braces springing from stone corbels, having upper and lower collars, and queen and king posts, the ceiling being immediately above the lower collar-beam. The timbers below the former are all stained and varnished throughout.

The boys' and girls' schools are all well lighted, having eight large windows inserted in the walls of each, divided by mullions and transoms agreeable to the style adopted. The windows are glazed throughout with Hartley & Co.'s ribbed opaque glass, to avoid the necessity for the use of blinds; they have also Moore's patent ventilating shades. The class-rooms have two corresponding windows fitted in a similar manner to those of the schools. Ventilation is also still further provided for by the application of air-grates in the ceilings, valvular plates in the floors, and tubes conducted to the backs of the fireplaces. The warming of the building is effected by Carter's stoves, which have hot-air chambers around them, in order to economise fuel and assist the ventilation in cold weather.

The teachers' residences consist of two houses in one block, but separated from each other and entirely distinct internally; the entrance to the master's house being in the passage leading to the boys' school, and that to the residence of the mistress in the passage leading to the girls' school; both of which are inclosed by iron gates. Each house contains the usual conveniences for domestic purposes.

We have been somewhat minute in the description of these schools, in consequence of their having been designed and carried out in accordance with the plans approved of by the Educational Committee of the Privy Council, and may form a guide in similar cases to the profession as to general arrangements.

The accommodation provided is for 480 children, viz., 240 boys and 240 girls, with residences for a master and mistress and their pupil teachers. The structure as combined has incurred a cost of about £3000, and is now nearly completed, from the designs and under the superintendence of Mr. A. D. Gough, architect, Lancaster-place, Strand; the contracting builders being Messrs. McLennan and Bird, Osnaburg-street, Regent's-park.

THE PATENT LAWS OF ENGLAND AND AMERICA.

The annual report of the Commissioners of Patents, which was printed in our number for September last, presents a very satisfactory view of the working of the new law, so far as regards the facilities afforded to inventors of becoming acquainted with inventions previously patented, and as regards the continued numerous applications to obtain the protection for inventions at a small cost which the existing law provides. The commissioners have at length completed the publication of all specifications of patents from the year 1628 to 1852, which fill 900 volumes, one half being occupied by drawings, and they have commenced the important work of printing abstracts of specifications, classed under different heads of invention, several of which have been already published, and it is expected that the series will be completed in eight or ten years. This publication will afford the means of ascertaining within a comparatively small space the nature of all inventions, from the origin of patent monopolies to the present day. It is impossible to over-rate the value of such information to inventors, most of whom now work in the dark, and very frequently spend years in endeavouring to perfect some contrivance which has been previously patented. The cost of printing the volumes of specifications in full has amounted to £92,000. Yet, notwithstanding this large outlay, the increased number of applications for patents, even at the reduced scale of charge, has been more than sufficient to defray all the fees and salaries, the revenue stamp duties, and the expense of printing the current specifications of the year, and there is now an estimated yearly balance of £30,000. This accumulating balance it is proposed to spend in the building of more suitable offices for conducting the business of the commissioners, for giving greater accommodation to the public in consulting the works of reference in the library, and for building, in the first place, a museum for the exhibition of models. Until those objects are accomplished the commissioners will not consider the question of a further reduction of the charge for protecting inventions.

Notwithstanding the great improvement on the patent law which was in force previously to 1852, neither inventors nor the public ought to rest satisfied with the law as it now stands, which, whilst it has removed many glaring abuses, permits others to remain as clogs on the progress of invention and on the improvements in manufactures. The average annual number of patents granted under the old law was 500, each of which cost the patentees at least £120 for England alone; whilst the present average number of applications for provisional protection amounts to three thousand, of which about two thousand proceed to the attainment of a patent for three years, at the official cost of £25 each. This increase of applications for the protection of inventions at the diminished charge shows how eagerly inventors

Digitized by Google

have seized the opportunity afforded them of placing the products of their inventive genius within the pale of the law; and so far it is evidence that the reduction in the price of patents supplied a want that was previously felt, and has remedied injustice; and were the charge still further reduced, there can be no doubt that many who are still withheld by their poverty would avail themselves of protection.

But the question arises, is this great multiplication of private monopolies desirable either for the public good or for the private interests of inventors? The public are always averse to monopolies, and senselessly decry all exclusive privileges in trade; as if a man who has by his ingenuity and skill effected an improvement in manufactures were not as much entitled to benefit by the produce of his own inventive faculties as a gentleman who inherits land from his ancestors is entitled to the produce of the soil. We are inclined to think that the title of the inventor to the coinage of his own brain should be more inviolate than the title to any other property whatever, though he is now compelled to pay specially for its protection. Nor are the exclusive privileges enjoyed by the patentee of a useful invention of the same selfish kind as the possession of most other descriptions of property. The public must derive benefit from the invention or they would not use it, and the limited term during which the privilege lasts would be considered an unjustly short time for the possession of other property from which no public advantage is gained. In another point of view also the public are materially benefitted by conferring the rights of private property on inventions, for by so doing encouragement is given to inventors, and without some such inducement our manufactures would fall into decay, the progress of improvement and of civilization would be stopped, and the prosperity and even the existence of this country as an independent kingdom would be destroyed. When, indeed, it is considered that the wealth and importance of Great Britain have been created and are maintained essentially by the ingenuity of inventors, it is most extraordinary that any prejudice should exist against them as a class, and that every facility should not be rendered to the fruition of inventive genius.

The apology for the maltreatment of patentees is to be found in the abuse, not in use of exclusive privileges. The swarms of useless impracticable contrivances to which exclusive privileges are granted completely swamp the few really valuable inventions for which special protection is applied; and the indiscriminate uninquiring grant of monopolies to all applicants, provided they conform to specified rules, becomes a more serious grievance to inventors than it is to the public in general. It not unfrequently happens that a patent for an invention utterly worthless of itself makes claim to some application of a material, or to some combinations of machinery, which prevents the practical and useful application of them in other inventions; and there is not in this country, as there is in France, a limited time beyond which if an invention be not brought into use the patent is forfeited. The multiplication of patent monopolies since the new law came into operation has vastly increased the difficulty of deciding questions of conflicting claims, and it has thus seriously added to the evils which inventors previously experienced. The practical effect of the operation of the existing law is to deprive patented inventions of their value, by rendering their validity uncertain, and though the fresh cost of a patent be cheaper, its maintenance, if the invention be valuable, is rendered more precarious and more costly. Every one has a wholesome dread of going to law, and many prudent men lay down the maxim that it is better to abandon any claim than to defend it; therefore the cheapening of patents, by multiplying the probable competitors, has tended to deprive inventors altogether of the advantages they anticipate by obtaining supposed monopolies which prove delusive.

The bill for the improvement of the patent law as introduced into parliament contained clauses which provided for a searching investigation into the merits of each application for a patent, but those provisions were withdrawn, and now patents are sold to all purchasers indiscriminately. The evils of this indiscriminate grant of special privileges are increasing daily, and the interests of inventors and of the public demand a reform of the practice. Whilst we would give freely and liberally to genuine, practical, and useful inventions all the protection which other property claims, we protest against the distribution to all applicants of monopolies which cannot, in one case out of a hundred, be of any use, supposing them to be effective, and which from their numbers render the protection they profess to give a delusion.

Contrasting with the comparatively brief report of the English Commissioners of Patents we have before us the voluminous documents, recently published, presented to Congress by the American Commissioner of Patents for 1856. They occupy three thick octavo volumes, two of which are chiefly filled with brief descriptions of all the inventions patented during the year, and the third volume contains woodcut illustrations. The report comprises a descriptive and illustrated account of 2502 patented inventions, and forms a valuable store of information to inventors. That large number of patents granted in 1856 does not include more than half the applications for protection during the year, for in the United States no patent is granted without previous examination.

The actual number of patents was nearly equal to those granted to all applicants in England, notwithstanding the previous ordeal of examination, from which circumstance we are led to infer either that the examiners are not very strict in their investigations, or that a great many more useful inventions are generated in the United States than in Great Britain.

It is curious, if not instructive, that while in this country we are complaining of the want of a previous examination, and recommending its adoption, the Commissioner of Patents in America recommends a relaxation of the powers of the examiners, so as to render the decisions of the patent officers not peremptory but merely advisory. On this subject the commissioner observes, "I feel firmly impressed with the belief that we shall come to this result at last, and that the right of an inventor to protection will not be left to the arbitrary determination of any officer under the government." The commissioner further recommends the adoption of the principles of the English patent law as regards the grant of a provisional protection, the gradual extension of the term by subsequent payments, and the printing of specifications separately. The receipts of the American patent office are not sufficient to meet the expenditure, and the commissioner suggests the propriety of increasing the rate of patent fees, which are at present less than half those charged in England. It may be mentioned, as an indication how much greater interest is taken in the subject of patents in the United States than in this country, that by a resolution of the House of Representatives sixty thousand copies of this voluminous report were ordered to be printed; fifty thousand being for the use of the House, and ten thousand for the use of the patent office.

UNIVERSAL SYSTEM OF WEIGHTS AND MEASURES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—The papers have announced that the fourth general meeting of the International Association for obtaining a Uniform Decimal System of Measures, Weights, and Coins, will be held on October 10th, in St. George's Hall, Bradford, and that M. Michel Chevalier, vice-president, will take the chair. This meeting has for its object the adoption of the *metre*, the *gramme*, and the *litre;* that is to say substantially, the adoption by England of the French decimal metrical system. If this system has not been put in practice here, it is undoubtedly because people perceive that it is far from perfect, and that if it unites certain advantages compared with the existing anomalousness of weights and measures, it presents also great inconveniences. In fact, each unit of weight and measure, as well as its multiples and sub-multiples, cannot be divided without fractions by a fourth, and without a remainder either by a third or sixth. This system comprises neither the geometrical measures nor those of time. It is evidently defective and incomplete; and M. Michel Chevalier, with all his science and St. Simonian logic, will never be able to prove the contrary. If this system is greeted here with a sufficiently numerous body of adherents, it is only because they ignore the fact of a superior and more perfect method which can be substituted for it. Now, since its introduction into England is seriously contemplated, and that such a proceeding would lead to consequences exceedingly detrimental for the future, it is time to enter the lists and attack it courageously.

The question is important: do *they* wish England to be the imitator of a tame and imperfect thing; or rather do *we* wish she should herself take the initiative, and offer to the world a work worthy of the nineteenth century? that is to say, a system logical, complete, harmonious, superior to all the methods of calculation at present in use, and combining all the advantages of the decimal system without presenting either its inconveniences or anomalies; in a word, a system in accordance with the advancement of our present knowledge.

It is a matter then of nothing less than the pre-eminence of Great Britain in respect of her method of calculation. Now, she might claim this pre-eminence for centuries; but on condition of simplifying arithmetic so as to accelerate the progress of art, science and industry, shackled by the old methods.

Digitized by Google

When England undertakes such vast projects,—when she makes immense sacrifices to construct Leviathans,—when no cost can deter her from flinging her endless telegraphic wires to the bottom of the ocean; why should she not undertake the enterprise of giving to the world a new system of calculation which would be a universal boon!

But some one will say, where shall we find this famous system? I answer, it is not difficult, since it is in existence, the fruit of the combinations of many years: this work is now about to be published to the world, and to claim its right to live.

Let there then be formed from this day an association in earnest, at the head of which let there be placed some influential men, and the preliminaries of reform will be immediately set on foot. Let the Rational Calulus and the universal system of weights and measures be examined and rendered more perfect if possible; then let its teaching commence in the universities, colleges, and schools throughout the country, and before twelve years have elapsed the nation itself will demand from government the enforcement by law of the new calculus. The other nations would follow the example of England, and France herself would see the necessity of abandoning the decimal system.

Impatient people will say "twelve years is a very long time." But is it not better to wait twelve years, nay even twenty, and to have a perfect and definite reform, than to commence a few years sooner and only have a transitory improvement, compounded of good and evil, not answering to the wants of the age, and which it would be consequently necessary to abandon sooner or later for a better system.

Since fabulous sums are expended every year in armaments, since enormous donations are given by rich personages for objects whose utility is at least questionable, can we not find a few thousand pounds for undertaking the greatest work of modern times—a work which would render illustrious an entire century; would merit the gratitude of future generations, and would consequently transmit the names of its originators with honour to posterity.

Eminent and practical men should reflect; it is a matter which involves the honour of this country; those above all who sincerely desire the diffusion of knowledge and the spread of science should not lose the opportunity of rendering themselves illustrious; and one day their names will be engraved at the base of that monument which the nineteenth century has received commission to erect to the glory of science, art, and industry. Does England understand her mission? Let us hope so.

October 5th, 1859. F. RIEMANN.

NOTES OF THE MONTH.

Moorings for the Great Eastern.—The moorings for the great ship in Southampton Water, have just been selected in Portsmouth Dockyard. The north arm of the moorings will consist of an anchor of 95 cwt. laid up the river, with 60 fathoms of chain, the two together weighing 18 tons. The south arm, with the anchor laid down the river, is precisely similar. The east and west arms of the moorings will consist of two blocks of 7 tons each, laid across the river; each with the chains weighing 19¾ tons. The four arms will be connected by a shackle, weighing 20 cwt. 26 lb., tested with a strain of 108 tons. From the shackle extend two pendants, 7 fathoms each in length, the links being 3¼ in. diameter. To the pendants are attached the two bridle chains of 6 fathoms each, with links 3 in. diameter. The weight of the moorings will be, exclusive of pendants and bridle chains, about 78 tons.

Straightening a Chimney Stalk.—The operations for restoring the colossal chimney at Port Dundas to a perpendicular and safe position are now successfully completed. This was accomplished by sawing several of the mortar beds between the courses on the side from which the chimney leaned, thereby allowing it to come back by its own weight, without the application of any external force. Only one draft was cut at a time, to guard against any shock which might have endangered the stability of the building, and by keeping the saws wet a bed of mortar was prepared for the superincumbent weight to settle down upon. Twelve cuts were made in this manner, on different parts of the structure, which generally set before the saws had passed through half of the circumference, particularly in those made nearest the ground where the weight was greatest. This method, which has been attended with complete success, was adopted by the advice of Mr. Duncan Macfarlane, architect. The principal dimensions of the chimney are:—Total height, 468 feet; from surface to top of cope, 454 feet; outside diameter at foundation, 50 feet; at surface, 34 feet; at cope, 14 feet. According to calculations made by Prof. Rankine, the building, independent of the adhesion of mortar, is capable of sustaining with safety a lateral pressure of 66 lb. per superficial foot at its weakest point, being 11 lb. more than the force of the greatest storm registered in this country.

Metropolitan Waters.—The waters used in London during the past month have been analysed by Dr. R. D. Thomson, F.R.S., of St. Thomas's Hospital. The Thames waters which have for some years been derived from above Teddington Lock exhibit comparatively a small amount of matter in solution, in consequence of the dryness of the season. The waters supplied by the other companies contain a somewhat greater amount of impurity. For the sake of comparison the water of Loch Katrine, which must for the future represent the type of a pure supply for towns, is added for the sake of comparison, together with the composition of an unhealthy metropolitan shallow well:—

Description of water.	Total impurity per gallon.	Organic impurity per gallon.
	Grs. or °.	Grs. or °.
Distilled water	0·0	0·0
Loch Katrine water, new supply to Glasgow	2·14	0·8
Well, Grosvenor-cottages, Pimlico	82·40	8·0
THAMES COMPANIES:—Chelsea	15·96	1·0
Southwark	14·76	0·96
Lambeth	16·00	1·36
Grand Junction	15·52	1·60
West Middlesex	15·60	1·84
OTHER COMPANIES:—East London	18·76	1·16
New River	17·32	1·16
Kent	23·84	1·72

The table is read thus: Loch Katrine water contains to the gallon 2·14 degrees or grains of foreign matter in solution, of which ·8 degrees or grains are of vegetable or animal origin.

Removal of the Paintings from Marlborough-house.—The whole of the paintings forming the English portion of the National Gallery, the Vernon and Turner collections, &c., which for some years past have been exhibited to the public at Marlborough-house, Pall-mall, were lately removed to the new building erected for their reception at Kensington-gore, and there opened to view on the 24th ult. The Wellington funeral car is to be removed to Chelsea Hospital.

Buildings in London stopped during the last three months in consequence of the Strike.—Among the important buildings lately stopped is the large town mansion for the Duke of Buccleuch at Whitehall, of which Messrs. Holland and Hannem are the contractors; the Westminster-hotel; new church in Baldwin's-gardens; new church at Holloway; the new Law Library, and other works, for which Mr. Myers is the contractor; the extensive improvements to the Middlesex Sessions-house, Clerkenwell-green, for which Messrs. Thomas Piper and Son are contractors; the new wing to King's College-hospital, which was commenced by the Messrs. Lucas Brothers. These structures as intended to be carried out will involve an outlay of upwards of £250,000. There are numerous minor works suspended that would swell the money value of the works stopped to upwards of £300,000. It is consolatory to know that notwithstanding the strike, several works have been vigorously proceeded with both in the city of London and in the suburbs, their builders having had the pick of the artisans in the metropolis, in consequence of the more eminent masters in London having locked them out.

Ancient Domestic Architecture of Great Britain.—We learn that an extended practical work on this subject is about to be issued by Mr. F. T. Dolman. It will be published in monthly parts, the first of which is to appear in December next. The work will comprise 160 plates with letterpress description to each example, and will when completed form two royal quarto volumes. Mr. J. R. Jobbins is to be associated with Mr. Dolman in the undertaking, and judging from what has already been produced by them, there can be little doubt that the work will be in every way acceptable to the architect and amateur.

Competition.—Plans are required for laying out for building purposes part of the estate of Granton, near Edinburgh, the property of the Duke of Buccleuch; also plans for the different classes of houses to be erected. Premiums £75, £50, and £25. The plan of the land may be seen, and copies of the conditions of competition obtained on personal application to Mr. John Hawkins, C.E., Granton Harbour. Competitors must forward plans, with a copy of the conditions signed by them, under cover to Messrs. Gibson, 12, Charlotte-street, Edinburgh, on or before the 1st March next.

Digitized by Google

Digitized by Google

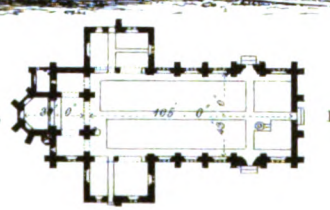


NEW CHURCH, MARCHINGTON WOODLANDS, STAFFORDSHIRE.

A D Gough Archt Lancaster Place, London.



William Smith Archt J.R Johbins



TRINITY CHURCH, HEIGHAM, NORWICH.

Digitized by Google

ST. JOHN'S CHURCH, MARCHINGTON WOODLANDS.

(*With an Engraving.*)

This village church, now named St. John's, was consecrated on the 6th of September last. It is completed with the exception of the upper part of the tower and spire, which ultimately will receive a peal of bells; the execution of this part is deferred until next spring. The style adopted is the Geometric Decorated of the fourteenth century. The structure is rectangular, consisting of nave and chancel; chancel chapels, north and south; a north-western tower and broach spire, an open timbered south porch, and an octagonal vestry. It is substantially built with grey and white Hollington stone. Its open timbered roof is covered with brindled Staffordshire tiles. The internal dimensions are,—length of nave 50 feet by 20 ft. 8 in.; chancel 21 ft. 8 in. by 14 feet. The pulpit, desk, and pewing are throughout of English oak. The accommodation provided is for 225 persons. The chancel arch and corbels from which the roof-timbers spring are of alabaster, from the neighbouring quarries at Fauld. The arcades separating the chancel and side chapels are supported upon polished shafts of Derbyshire marble.

The artistic carving has been admirably executed by Messrs. Purdy and Outhwaite, of Dublin. The stained glass in the chancel is remarkably well drawn and executed by Mr. Charles Gibbs, of London. The general contract has been carried out by Mr. Evans, of Ellastone, Derbyshire, from the designs and under the direction of Mr. A. D. Gough, architect, Lancaster-place, London.

TRINITY CHURCH, HEIGHAM, NORWICH.

(*With an Engraving.*)

At the commencement of the present year, plans were submitted in competition for the above church; and we now give an illustration of the design selected.

The requirements of the committee were so much beyond the usual proportions of accommodation and expenditure, that it would seem perfectly clear that no elaborate design ought to have been submitted; yet we find that a considerable number were of a highly decorative character, the execution of which with the means proposed was manifestly impossible. Accommodation was required for 1200 persons; galleries were forbidden; and the cost (exclusive of any tower, but including the architect's commission, and salary of the clerk of works) was limited to £4500. Sixty-four designs were submitted in competition. The committee after a careful examination, and with the aid of one or two practical men amongst their number, selected the design of Mr. William Smith, of New Adelphi-chambers, as the one which best fulfilled all their instructions. A tender was soon after accepted from a builder at Norwich, he agreeing to execute the works for £4000; and the building is now rapidly progressing. The materials used for the walls are brick and flint, with Ancaster stone for all the dressings. The internal fittings will be of deal varnished.

ON THE REMAINS OF PAINTED DECORATION IN SOUTHWOLD CHURCH, SUFFOLK.

There is hardly any subject more interesting perhaps, whether viewed archæologically or otherwise, in reference to architecture, than that which is embraced in the consideration and study of the coloured decorations once so largely employed to add effect to and adorn the buildings of former times, and particularly to us, of those of this country. On the many pleasurable sensations created, or for the artistic effects produced by a proper disposition and introduction of colour and painting for such a purpose, it is unnecessary to enlarge or contend. Such are and always have been patent to a great extent. The untutored savage appreciates and eagerly appropriates the coloured beauties of nature with which he is surrounded; while the educated eye and cultivated sense derive an increased amount of pleasure in the contemplation of equivalent aids in the embellishment of the material fabrics on which in a more civilised condition they are accustomed to rest. Spring, in the imaginative language of the Saxon dialogues (see Turner's 'History of the Anglo-Saxons,' vol. iii., bk. 7, chap. 2), is called "the painter of the earth," and the sentiment conveyed in the expression is traceable to the innate feeling for the beautiful, which nature disposed in her mantle of many colours, in common with almost every other object properly thus clothed, awakens in and is the exponent of, more or less sensibly, to us all.

Having premised thus briefly in allusion to the general subject, the claims of which the late revived consideration of the matter is, in fact, an admission of, it may not be without profit to call the attention of the professional and other inquirer to an example of Mediæval decoration of this description, still to be observed in this country in more than the fulness usually found, and, comparatively speaking, in a condition less than ordinarily defaced. In this instance it is an application to the case of the church, that careful foster-mother of the arts of the middle ages. Hereafter it may possibly be considered necessary to continue our notice to similar adoptions of the practice in domestic erections of the same period, and to found on such, considered together, some practical observations in reference to the modern employment of similar ornament.

Along the east and north-east coast of England—and the fact is interesting as an illustration, as the paintings themselves in many cases also are, of foreign influence as respects admission and character—there are a number of fine churches all of which appear to have exhibited formerly a large amount of painted and pictured decoration; for the introduction of which, it is probable, their proximity to and a frequent communication between this part and the Low Countries may have afforded facilities beyond such as extended to or were felt in more inland parts. A map on which should be indicated the Suffolk and Norfolk churches more particularly so decorated, would show this very distinctly, examples increasing largely as the coast is approached. In some of these the evidences of their former state in this respect are still discernible, and of that of others there are several instances of very explicit record. In none of these, however, are they now to be seen so fully developed or in so comparatively well preserved a condition as in the Church of Southwold, lying immediately next the sea, about 11 miles south-west of Lowestoft. This church was originally an appanage, or chapelry, attached to that of St. Margaret at Reydon, a short distance inland; Southwold being a hamlet of that parish. The first notice of it, or rather of an ecclesiastical edifice at this place, occurs A.D. 1202, the 16th of Henry III., when by the arbitration of John, bishop of Norwich,—in a matter in dispute between the abbot and convent of Bury as lords of the manor of Southwold, and the prior and monks of Thetford, in right of their cell at Wangford patrons of the church of St. Margaret at Reydon, then called Rismere,—respecting provision for the cure or ecclesiastical wants of the place, it was decreed that the said prior and monks should build a chapel at Southwold, which should form a chapelry and be in all respects subservient to the mother church at Reydon; the abbot and monks of Bury, whose tenants the inhabitants were, providing a site for the purpose, and paying towards the stipend of the chaplain thereof, to be nominated by the monks of Thetford, 40*s.* annually.

Of this first chapel, which it is probable was soon after this decision erected, we possess only the information that it was destroyed by fire about 230 years after, and sundry references to it in the Institution books of the diocese of Norwich, which record the presentations to Reydon "cum capella de Southwold," in the interval which elapsed between the erection of the first and the existing edifice. Such portions of the older one as may have remained after the fire were doubtless removed to make way for the present.

The earlier building here referred to, from the date of its erection before mentioned, must have been of Early English character, the present is fully developed Perpendicular; a style which characterises most of the existing Suffolk and Norfolk churches, particularly of the coast line, and of which Southwold and the neighbouring churches of Walberswick, Blythborough, and Covehithe may be classed among the finest examples. Erected coevally or nearly so with each other, these churches may be considered the churches *par excellence* of this part of the country.[1] We are fortunately in possession of minute and careful record as respects the building and completion of the two first-named of these churches—that is to say, Southwold and Walberswick, which latter like its neighbour appears to have been a re-edification and elaboration of an older building—from which we learn the exact date of their erection, the nature

[1] The tower of Blythborough appears to be of earlier date, but the rest of the church corresponds with that of Southwold.

Digitized by Google

and cost of their decorations and furniture, as well as many other particulars highly interesting and valuable in relation to their history, and to the subject more especially of our present consideration.

From the sources here alluded to we gather not only the dates of the main construction, but of many of the subservient interior fittings and ornaments. The latter it is the object here more particularly to notice. In 1460 (January 24) a legacy of £20 is given by will ("ad fabricam novæ trabis candelarem") towards making the new candle-beam; and in 1461 (October 18) another legacy ("ad facturam scamnorum") towards making the benches or seats, occurs in the will of one William Grantham.[2] This candle-beam formed, doubtless, a portion of the upper part of the present chancel screen, one of the principal painted objects in this church on which remark will be more fully entered into presently. Though in several instances the candle-beam occurs in old churches as a separate and independent beam across the chancel—as at Ufford in the same county, where it appears to have existed above and unconnected with this feature—yet in many others it was a portion of the screen itself, and which the largeness of the sum bequeathed (more than £120 of our present money) would go far to establish was also the case here, as it was at Walberswick, where it is referred to in connection with the rood stairs or means of ascent to the rood loft or gallery over the screen, as follows, viz., "1449, payd Thos. Callyng for making of the vyse unto the candelbem, 1*l.* 8*s.* and 10*d.*," also to the same "for steppys of the vyse on to the kandylbem, 4*s.* 8*d.*" A similar staircase exists at Southwold, as it does in very many other churches, and no doubt led in like manner to the gallery or loft originally above the screen, here associated in description, from the custom anciently observed on the feast of Candlemas of fixing lights on its top, of which an instance occurs in the churchwardens' accounts of All Hallows, Bread-street, London, where the same was sometimes lit up with twenty-two tapers weighing 67 pounds,[3] with the use so made of it.

Coevally or nearly so with the date of the bequests here mentioned for the erection of the screen, the progress in respect to the other internal decorative features must have been going on. Soon after 1489 the painted figure of the Blessed Virgin with its appropriate canopy was part of the furniture of the Lady-chapel, in accordance with a custom founded on a canon of the Anglo-Saxon church, made A.D. 816, which enjoined that the figure or picture of the particular saint in honour of whom the same was erected should be placed in its respective chapel; as we find from the will of Thomas Molesharp, in which he directs two images with their tabernacles to be therein fixed: "Item, volo qd. Johannes Conyver Gaver perficiat duo tabernacula in ecclesiâ prædictæ (S. Edm. Southwold) cum duabus imaginabus in honore annunc. B. Mariæ Virg. et altera in honore Gabriel ipsam secundum qd. conventum est. 1489 (Nov. 25). In testamento Thomæ Molesharp."[4]

This image of the Virgin, with that of St. Gabriel, as may be expected, no longer occupies its ancient place. It was however, as customary, richly adorned with painting and gilding to match the other and similar ornaments of the church, as we learn from the will of Katherine Browne, who directs a like decoration of the image of the Blessed Virgin in the adjoining church of Walberswick:—"1503. Item, I will that my executors do paynt and gylde the tabernakyle of our Lady of Pety at my cost, according to the form of St. Mary of Pety of Southwold."[5] In 1518 and 1522 we have similar bequests. Richard Marsh gave by will (dated 4th December in the former year), "ad fabricand novi tabernaculi St. Johanne, 6*s.* 8*d.*, et picturæ ejusdem, 6*s.* 8*d.*:" and in the latter, Mary Joye, among other bequests, gave £4 sterling "to bey two banner clothys, oon of the Trinity, and another of our Lady of Pyte;" she also at the same time gave "to the guilding of the tabernakyll of St. Savyor."[6] These banner cloths contained, doubtless, the usual embroidered representations in coloured silks and silver, and formed a further part of the furniture of the chapel of the Holy Trinity at the end of the north aisle, and of that of the Blessed Virgin at the east end of the opposite or south aisle, to be used probably in the procession on the appropriate feast days of each, and on other occasions to be suspended and take place with the hangings and more stable coloured decorations of the walls; of which latter such embroidered representations in the shape of hall cloths—"*wah reafes*," as they were called in the Saxon times—were the original prototypes.[7]

At the same date with all these bequests here noticed, and the execution of the works as respects Southwold, towards which they were made, similar applications of painting were being exhibited in the adjacent mother church of Reydon and at Walberswick, both in the older and later church of the latter place. The ceiling of the chancel of the first mentioned was painted in 1460. "1460, In testamento Johannis de Southwold (Jan. 24) ad picturam celaturæ cancelli de Reydon, 18*s.*";[8] and this probably gives the age of that of Southwold, in which it agrees with the date of the gift towards the candle-beam or screen. In the elder church of Walberswick were paintings in the shape of tablets of St. George and Henry VI., which were removed with the painted windows of St. Christopher and St. Wolstan, on its demolition in 1473, into the new church. In 1479 we find a charge for fixing the first mentioned of these pictures, which would appear to have been partly inserted in the wall. "1479, payd for brokyng down the walle where St. George standyth, 6*d.*;" "for a cloth for St. George," probably a curtain to draw over the picture, "and a halbe 2*s.* 6*d.*; and "for yrennys and wyer to the tabal of St. George, 6*d.*"[9] In 1483 there is a charge for the painting of St. John's altar, 8*d.*, and in 1487 an entry as follows, viz., "payd the glaswryte for mendyng Seynt Krystefery's wyndown, 8*s.* 4*d.*," and "for mendyng Seynt Walsteny's wyndown, 9*d.*;[10] works or reparations doubtless attendant upon their being placed in their new situations. In 1489 the will of one Robert Dolsynby directs the making of the image of "Seynt John Evangelist and the tabernakyll thereto, according to the makyng of Seynt John Baptist," and the painting of both at his cost.[11] In 1491 we have, "payd for peyntyng of our Lady, 13*s.* 4*d.*:"[12] and in 1498, "Recd. by a gatheryng in the towne, to peyntyng of the salyng (ceiling), 3*l.* 5*s.*"

This gathering seems to have very inadequately met the expense of the painted ceiling of Walberswick, inasmuch as we find the cost of it, with that of the crucifix, amounted to £11 10*s.*—somewhere about £69 of present value, as appears by the following, viz., "1498, payd William Rede and William Sharft, for peynting of the crusyfix and the selyng, 11*l.* 10*s.*"[13] The crucifix here alluded to was without doubt the image of the Saviour, and its accompanying figures of St. Mary and St. John, which occupied a similar position to a corresponding representation of the rood at Southwold; in connection with which in many of the Suffolk and Norfolk churches, it is to be observed, a large amount of decoration is apportioned to the ceiling, and shows itself more particularly in the bay of the same which overhangs the rood figures.[14] This at Southwold is of very enriched character, as it was probably, from the largeness of the cost, at Walberswick; and this will bring us to one of the most perfect of the painted features which the former church contains, the detailed and particular description of which, having so far followed the historic records of their introduction, both here and incidently in the case of its more immediate neighbours, may now be proceeded with.

The roofs generally of Southwold church are the kind usual in the churches of this district; those of the aisles are flat lean-to roofs, that of the body the open timber hammer-beam, the chancel portion being ceiled in panels beneath the rafters, the rest uncovered to the ridge, as commonly the case; a deep cornice

[2] Wills in the Beccles Office. See Gardner's History of Dunwich.
[3] See Nichol's Loudinium Redivivum, vol. i. p. 21.
[4] Wills in Beccles Office.
[5] Walberswick Church Accounts.
[6] Wills in Beccles Office.

[7] These embroidered cloths, used as wall-hangings and as coverings to the altars, appear under their Latin name of "Pallia," and those of "Cortinæ" and "pictes vestes," painted vestments; as well as under the Saxon name of "wahrift." The terms "heall wahrift" and "heall-reafes" occur: they were formed of needlework and woven threads (see Turner's 'History of Anglo-Saxons,' quoting Ingulph., and Aldhelm notices their being stained with purple and different varieties of colour. See Blackburne's 'Decorative Painting of the Middle Ages.'
[8] Gardner's History of Dunwich, quoting Bishop Tanner's MSS.
[9] There is a payment to Edmund Wryte in 1497 "for removing of King Henry's tabell."
[10] Walberswick Church Accounts.
[11] Tanner's Collections.
[12] The image of our Lady was no doubt the same which existed in the elder church, and for "peynting" which there is an entry in the church accounts under the date of 1453, of 5*s.* It appears to have stood in the north aisle of the new church, probably in a chapel screened off at the east end, as that of Seynt John Baptist did in the south aisle; both figures being referred to in the will of William Rysche, 1518, as occupying these situations. There is great variation in the position of the Lady-chapel more particularly, as well as that of others in old churches. At Southwold it was at the east end of the south aisle, and the same at Blythborough. At Durham it was at the west end; at Compton, Surrey, and Compton St. Martin, Somersetshire, with Darent, in Kent, it was over the chancel; at Fordham St. Mary, Cambridgeshire, over the porch; at Canterbury Cathedral, under the choir; at Bristol and Ely, on the north side of the choir—in the latter a separate building; at St John, Maddermarket, Norwich, South Elmham and Castle Acre, Norfolk, and Croydon, Surrey, with Walberswick, as just mentioned, it was at the east end of the north aisle.
[13] Walberswick Account Book.
[14] At Cratfield the ceiling over the place of the rood is more highly ornamented than the rest.

Digitized by Google

connects the feet of the rafters with the lateral walls; and the arch braces, hammer-beams, purlins, and other timbering, are richly moulded throughout, the panels of the chancel being divided by intermediate ribs, with the usual carved bosses at their several intersections. The whole of the woodwork here is covered with painting, as far westward as the bay immediately over the screen separating the chancel from the nave, in more or less perfect condition. The panels have been a bright blue studded, except in the bay above the screen just mentioned, with gilded stars cast in lead, in relief.[15] Most of these latter have disappeared, but their places are sufficiently well indicated. The moulded ribs between the panels have the inner hollow next the panels white with red fillets; the first ogee, next this, is red; the next, which is the first of the mouldings of the main beams, is waved green and white, the beads in each case being banded spirally dark blue and white. All the bosses and angle flowers are gilt. The large cornice is similarly treated, the beads being banded blue and white; the ogees waved green and white; fillets white against red hollows, and red against white hollows; the large curve or hollow is red, with a white scroll pattern between carved figures of cherubim and angels, coloured and gilt. The inferior arch braces have their spandrels painted with imitative tracery, white on differently coloured grounds; the flat or arch faces of the main braces of the principals have been ornamented with scroll foliage, and other similar patterns conventionally treated, and the hammer-beams on which these latter rest are carved representations alternately of cherubim and angels—the former gilt, the latter in white robes and golden wings.

(To be continued.)

ON THE PRINCIPLES AND PRACTICE OF CIVIL ENGINEERING.

A Course of Lectures delivered at the Royal Engineer Establishment for Field Instruction at Chatham.

By HENRY CONYBEARE, F.G.S., M. Inst. C.E.

LECTURE V.

On the Permanent Way of Railways.

(Continued from page 356.)

Mr. Barlow then arrives at the conclusion that till greater perfection can be obtained in railways a strength of from 10 to 20 per cent. more than double that due to the mean strain must be provided so as to allow of a safe surplus. Since the date of Mr. Barlow's experiment the general introduction of the fish-joint and the greater attention paid to the accuracy of gauge and cant of rails have probably diminished the increment of deflection due to the concussion from side lurches occasioned by such irregularities; but far less attention is paid to these details in England than their importance requires; and we may therefore assume that from these causes a pressure is still occasionally exerted on the rails equal to double that of the load in a quiescent state, and that with a weight of 11 tons on the pair of driving-wheels a pressure equal to 11 tons would sometimes be exerted on a single rail. And this is a pressure considerably exceeding the limit that a square inch of rail iron can bear without crushing; but the contact of the conical wheel with the slightly curved contour of the wheel-tread could only be a mathematical point, unless the elasticity of the surfaces in contact allowed of a partial flattening of the periphery of the wheel, and of the rail deflecting and lapping round the wheel immediately about the point of contact. And it is evident that unless this action really took place the rail must inevitably laminate and roll out under heavy engines; and it is equally evident that this elasticity which alone saves the wheel from destruction must be greatly checked by increasing the rigidity of the rails or substructure: there must be a compromise between the non-deflection essential to theoretical perfection, and the amount of elastic deflection that the softness of the material of the rail renders essential to its longevity. It is well known that the most striking instances of longevity in rails have occurred in cases in which the amount of deflection is exceptionally great: for instance, Mr. Errington and Mr. Strap, the engineer in chief and resident engineer to the South Western Railway, have remarked on the astonishing manner in which a length of 25 or 30 miles of the original rails of the South Western, 75 lb. on 5-feet bearings, continue to withstand the great increase in the speed and amount of traffic and weight of engine to which they have been subjected. It was proved by Barlow's experiments that, the strength being the same, the amount of deflection of a 5-feet bearing to a 3-feet bearing was as 64 to 24, in other words, that the elasticity of the former was nearly threefold that of the latter.

The effect of over-rigidity was very well illustrated by the well known experiment that Mr. Hartley tried in a sandstone cutting on the Leeds and Manchester Railway. He fixed his rails to the live rock, with the object of making them "as firm as the bed of a lathe:" the result was, that the rails were beaten to pieces like a piece of hoop iron between a sledge hammer and an anvil, and the line had to be relaid with wooden sleepers.

Mr. Stephenson has observed, that it is imperative to arrest the impression which was entertained by some persons that it was desirable to obtain a perfectly rigid road: Mr. Stephenson's experience had led to exactly the opposite conclusion. It was quite true that a rigid road might theoretically speaking be considered the best, but in practice it was the worst; for although from its rigidity it might offer the least resistance, it increased the wear and tear prodigiously. His attention had been called some years ago to the fact of the rails in the Watford Heath cutting, on the London and North Western, being split and crushed to such an extent, that although the cutting was through gravel the rails were removed two or three times. On a personal examination of the spot he soon perceived that the destruction of iron arose entirely from the gravel having been extremely well consolidated, and the stone blocks so firmly bedded and packed, that the line was rigidly unyielding, and consequently the iron rails were literally crushed under the fast traffic.

Experience has proved that a double-headed rail of 70 or 71 lb. to the yard, 5 inches deep, and with bearings from 3 feet to 3 feet more apart, possessed quite as much rigidity as was requisite, and greatly more than the eighteen years' experience of the 75-lb. rails with 5-feet bearings on the South Western Railway had proved to be necessary; for the deflection of a 70-lb. rail with 3-feet bearings would be under ·03 of an inch with an engine having 11 tons on the driving-wheels, and the deflection of the 5-feet bearing under an equal load would be more than double that amount, probably at least ·07; yet this rail had lasted longer than any other on record exposed to an equal traffic.

It has been found on the South Western Railway that a 58-lb. rail with 2 ft. 7 in. bearings (De Bergue's) stands well under the traffic. Mr. Errington states "that there is no lamination at the rails, and that he found that the upper surface was less injured, and that there was less difficulty in keeping the road in order than with other rails weighing 80 lb. per yard on the same line, which were stripped and much injured. On the South Western Railway the original rails were double-headed, weighing 75 lb. to the yard, and with bearings 5 feet apart. A considerable portion (25 or 30 miles) which had been laid sixteen years was still in existence, and in very good condition, notwithstanding that the weight of the engines and of the train as well as the speed had been much increased in the interval. In fact the joint was the main thing to be attended to; there was such a thing as too great strength, or rather rigidity, in a permanent way, in which case the iron was crushed."

We have thus seen that a double-headed rail (by no means the strongest form of section) of 75 lb. to the yard with 5-feet bearings has endured the traffic of a great trunk line such as the South Western for eighteen years; and this is no more than equivalent to a rail of 57½ lb. per yard on 3-feet bearings; such a rail would be equally strong and nearly three times as stiff as a rail of 75 lb. with 5-feet bearings. We have also seen that on the trunk lines in Belgium, with a traffic of 3000 trains a year, the duration of double-headed rails of 55½ lb. and on 3-feet bearings, is calculated on experimental data at 120 years, or as being equivalent to the transport of 360,000 trains during their lifetime; and that on the North Western line, with a traffic of 50 trains a day, Capt. Huish calculates the duration of rails averaging 70 lb. per yard on 3-feet bearings at 20 years, or in other words that the total number of

[15] This was common in many churches; and a long list of ceilings so ornamented might be given. In the chapel of the Blessed Virgin, in the Undercroft, at Canterbury, small convex mirrors were introduced and rayonated with gold: and at St. Mary's, Bury, similar mirrors or convex glasses were introduced set in lead, cast to imitate small masses of cloud. The practice seems to be of very early introduction here: in the Saxon dialogues the stars are called in reference to it, "the paintings of the summit of nature; the ornaments of night;" and roofs so decorated were considered to have a natural as well as symbolic allusion to the heavens. Stubbs, in his 'Actus Pontificum Eboracensium,' calls the ceiling of York Cathedral, "a splendid heaven." Malmesbury also describes that of Canterbury, completed by Prior Conrad, as representing heaven. See Blackburne's 'Decorative Painting of the Middle Ages,' quoting Turner's History of Anglo-Saxons; Willimott's Heraldic Notices of Canterbury Cathedral, &c. &c.

Digitized by Google

trains they are capable of transporting during their existence is $50 \times 365 \times 20 = 365{,}000$ trains, a result closely coinciding with that arrived at by the Belgian engineers, when the greater weight and speed of the English trains is taken into account. And the Prussian lines have been mostly laid with a 62-lb. rail on 3-feet bearings; and Mr. Hawkshaw states that he has travelled over these lines at 40 miles an hour, and that they appear to stand remarkably well. We therefore arrive at the following conclusions:—

That any amount of strength, or rather rigidity in the rail or substructure, that is over and above what is required to prevent an amount of deflection under the passing load exceeding the limits of elasticity, detracts greatly from the duration of the rail, by causing its surface to laminate.

That under the immense traffic of the North Western, rails of 70 lb. to the yard, 5 inches in depth and with 3-feet bearings, have been found to answer every condition, and that no greater depth or greater degree of rigidity than these dimensions involve should ever be adopted.

And that the experience gained on the South Western Railway, the Belgian railways, and the Prussian and other continental lines, sufficiently proves that on lines of smaller traffic rails of 55, 60, 62 or 65 lb. per yard will answer every condition, and last longer than heavier rails of less elasticity would do under the same traffic.

That most rails fail through imperfection of the joints and of the laying, and owing to the insufficient hardness of the metal of the bearing surface, and that if such surface could be case-hardened or steeled by cementation, it would greatly conduce to the longevity of the rail.

The first railways which were formed were wooden railways; they were introduced as a substitute for common roads in the mining districts about Newcastle, between the years 1602 and 1649. They are thus described in the life of Lord Keeper North:—"The manner of the carriage is by laying rails of timber from the colliery to the river, exactly straight and parallel, and bulky carts are made with four rollers fitting those rails, whereby the carriage is so easy that one horse will draw four or five chaldrons of coal; and is immense benefit to the coal merchant." Some roads of this description were still in use in that district when I was an engineering student at Newcastle, and they are possibly in use still. They are figured in 'Wood's Practical Treatise on Railways,' and consist of timber rails 4 inches wide by 4½ deep, trenailed down with a gauge of 3 feet to transverse sleepers 5 feet long and 5 inches square.

In some parts of the road, where occasional acclivities had to be overcome, thin plates of wrought-iron were laid upon the surface of the wooden rails and fastened down with common nails, to diminish the resistance opposed to the wheels and equalise the draught of the horse. The diminution of friction obtained by the use of these malleable iron plates led soon after 1738 to the substitution of cast-iron rails for wooden ones; and in 1768 the practice was introduced of linking together a string of small waggons in trains in lieu of a single heavy waggon, in order to diminish the load on each wheel, and distribute the weight over a longer base of rail. Cast-iron rails were introduced at Colebrook Dale in 1767.

Malleable iron rails were introduced by Mr. Nixon at the Warbottle Colliery, near Newcastle-on-Tyne, in 1805, but they did not come into general use until 1820, when Mr. J. Birkinshaw, of the Bedlington Iron Works, obtained a patent for the "fish-bellied" rail, which was at once largely adopted, and continued in use until after the opening of the Liverpool and Manchester and London and Birmingham railways, when, having broken down under the heavy and rapid traffic of the latter line, the defects of that pattern became palpable, and it ceased to be manufactured.

As we have seen, the earliest form of wrought-iron rail was the plate rail, consisting of a bearing surface or wheel-tread of thin plate iron spiked down to a wooden stringer, and this form was largely adopted in the earlier railways in America.

The next in order was the T rail, in which the bearing surface was supported by a vertical rib of metal instead of by a wooden stringer. The next was the double-headed or reversible or I rail, first practically adopted by Mr. Locke, on the Grand Junction Railway in 1835, with the object of reversing the rail when the upper surface was worn out. These two last forms can only be fastened to the substructure by the intervention of a "chair" of cast or wrought iron.

To get rid of this unnecessary complication two forms of rail were introduced, which admitted of being attached directly either to transverse or longitudinal sleepers, without the intervention of chairs: these forms were the Ω bridge rail, and the foot rail or contractor's rail, ⊥. This last form has completely superseded the bridge rail, the use of which in new lines is altogether abandoned. The contractor's rail has also superseded the T and the I rails in America and on the continent of Europe, and is rapidly gaining ground in England; the quantity of rails of this latter form now manufactured is more than threefold that of all the other forms put together.

It has been already observed that the form adopted in the earliest American railways constructed prior to 1834 was precisely that introduced two hundred years ago in the Newcastle coal districts, consisting of a plate of iron spiked to a wooden rail supported on transverse sleepers. For example; the permanent way of the New York and Pattison Railway consisted of a flat wrought-iron rail 2½ inches wide and ½-inch thick, weighing 12·60 lb. per yard, nailed to inner edge of timber rails 6 inches wide by 8 deep, notched into transverse sleepers 8 inches square and 7 feet long; the ballast consisting of broken stone was disposed in pits, 1 ft. 6 in. square and 2 ft. 6 in. or 3 ft. 6 in. deep placed beneath the intersection of the rails and sleepers. The gauge 4 ft. 8½ in.

These early American railways are described in a work, published at Paris in 1836, by M. Guillaume Tell Poussin, which enters into a full description of the whole of the American railways, describing the country, engines, companies' expenses, administration, &c., from which I have selected the following examples:—

The Philadelphia and Baltimore was constructed on the pattern of the double roads used two centuries ago in the Newcastle district, the ballasting being disposed in parallel trenches 18 inches wide and 1 ft. 2 in. deep, on which are bedded longitudinal sleepers 10 inches by 4 inches, supporting cross ties 6 ft. 6 in. by 8 inches square placed 3 feet apart, and supporting the rails, which are of oak 6 inches square, plated at the edge with a wrought-iron bar 2½ by ⅜ in. = 15·75 lb. per yard: each rail 15 feet long and fastened by 12 nails.

On the Portsmouth (U.S.) line the plate rails were only 2 inches by ½-inch, weighing 10 lb. to the yard. On the Shenectady and Saratoga, the plate rail weighed 12·60 lb. per yard. On the Columbian Railway, the Philipsburgh and Julian, and Charlestown and Augusta railways, the construction was generally similar, and the plate rails varied in weight from 10 lb. to 20 lb. per yard.

The most perfect example of the system of permanent way was afforded by the Utica and Syracuse Railway, the permanent way of which consisted of longitudinal sleepers on sills 6·12 inches by 4 inches, bedded in trenches filled with broken stone supporting cross ties 8 feet long, 8 inches wide, and 4 inches deep, trenailed to the sleepers, on which are laid pine wood rails 8 inches square, carrying hard wood (white oak) ribbons 3 inches wide by 1¼ inch deep, on which are laid the wrought-iron plate rails 2½ inches by ¾-inch.

I have dwelt at some length on the employment of the plate rail on the early American railways, because I think the application of the system of construction was a most judicious one *under the circumstances*, and that it might be applied with great advantage under similar circumstances in India and the colonies, in the construction of branch lines through districts where timber is abundant, where iron is dear, skilled labour is scarce, and the traffic has yet to be developed.

It is evident that such a system of construction as that employed in the early American railways, was cheaper than the construction of a good macadamized road, and that it carried goods and passengers far cheaper and much more rapidly than a macadamized road could have done; and that the money employed on its construction had an infinitely greater effect in developing the resources of the country than the investment of the same sum on the construction of one-fourth the mileage of a superior description of railway could have done.

The plate-rail system never attained in America the degree of perfection of which it is capable: the plate was generally too thin to distribute the impact of the driving-wheel over an area of timber sufficient to bear it without injury to the fibre. The fastenings of the iron plates to the timber rail were insufficient to resist the loosening effect of the expansion and contraction of the rail under changes of temperature, and the locomotive would

Digitized by Google

batter the rail down on the oak ribbon beneath with a violence of impact destructive to the fibre of the wood; and the joints being insufficiently secure, the ends of the rails occasionally got loose, and rising up like "snags," entered the passenger carriages, causing fatal accidents.

The first of these objections might be remedied by increasing the thickness of the plate rail to one inch. The second, by substituting screw bolts for the spikes, passing completely through the construction and secured on the under side, so as to combine the iron plate and timber rail into a single beam. The third defect might be remedied by welding the plate rails together, welding beneath each joint a plate of sufficient thickness to render that portion as strong as any other after deducting the loss of section. Two bolt poles, by which it should be fairly bolted through timber rails and cross sleepers in laying the rails, should be artificially heated to a point somewhat higher than anything to which it would be subjected to when in use; and the plates being then laid and fixed to the rail and sleepers in a state of tension, the fastenings would have no tendency to work loose, or the rail to buckle up.

Railways of this description would answer all the requirements of the small traffic, low speeds, and light engines that suffice for the wants of a new country; and whenever the traffic increased and the plates began to wear, they might be replaced by a contractor's rail of suitable strength, without interfering with the substructure.

It has been already observed that the bridge rail has fallen into disuse: there remains therefore only three forms to be considered, the T, the I, and the ⊥.

Each of these consists of, 1st, a "head" or upper flange, which forms the bearing surface or wheel-tread; 2nd, of a vertical rib, by the sub-position of which beneath the bearing surface the latter is upheld in its requisite unyielding condition; and 3rdly, of a lower web or flange.

The function of the head and vertical rib are the same in all three forms of rail, but not so the function of the lower flange. In the T rail its object is to give a maximum of stiffness with a minimum of materials to the section, but it also affords facilities to fishing the joints and fastening the rail. In the I rail the lower flange is made similar to the head; or in other words, the rail is double-headed, so as to allow of the lower surface being brought into use when the upper becomes worn. In the contractor's rail the lower flange is widened out, so as to admit of its being directly fastened to the sleeper without the intervention of chairs or keys.

We will in the first instance proceed to consider the conditions (common to all three forms of rail) which fix the width, depth, and profile of the head of the rail.

I have already remarked on the extreme pressure to which the bearing surface of the rail is subjected. The weight thrown on a single wheel by the side lurches of the engine is occasionally as much as 8 or 10 tons, a pressure that would require a surface of one square inch of wrought-iron to bear it without injury; yet the actual bearing surface, supposing both wheel and rail to be absolutely unyielding, would be only a mathematical line on the contact of a cylinder with a plane 2 inches long under the most favourable circumstances, and in ordinary practice only a mathematical point on the contact of two cylinders laid transversely to each other. Under these circumstances it becomes of the utmost importance in determining the profile of the wheel-tread to avail ourselves of the facility afforded by the partial elasticity of the iron for distributing the pressure to the greatest possible extent.

The top width of the rail has varied in practice from 2 inches to 2¼ inches; a portion of such width is necessarily non-effective, owing to the necessity of rounding off the shoulder. Thus in the early rails, the width of which was 2½ inches, the corners were rounded off by a quarter circle of a quarter of an inch radius, leaving the effective width of the wheel-tread only 2 inches. Thus the simplest profile of rail top is desirable. For the middle portion or wheel-tread and the curved shoulders on each side of it 2¼ inches will be as effective as 2¾ inches, and much stronger. Were the wheels cylindrical, and could every portion of the wheel-tread on which they worked be always maintained in the same horizontal plane, the pressure would be equally distributed over the whole width of the wheel-tread, and by extending such width the wear and tear might be proportionately diminished. And under such conditions the wheel-tread should be a plain surface as wide as possible, but under the actual conditions of practice the actual bearing surface of the rail must be always a segment of a cylinder; and with an actual contraction not exceeding ¼-inch in width, a width of contact exceeding ⅛-inch or under in most favourable cases is unattainable.

The reasons that render a round-topped rail inevitable are two in number; the first is the loosening of the wheels, and the second, and far more important, is the imperfection of workmanship. The object of coning the wheels is to enable them to run centrically between the rails, without any rubbing of their side flanges against the inside edge of the rail, and to counteract the centrifugal force in turning curves; and, in order to allow for any unavoidable irregularities in the laying of rails, and to assist the carriages round curves, a clearance, or windage as it would be called in artillery, is left between the rails and wheel flanges amounting to nearly an inch. The coning of the wheel tire is 1 in 20, and the rails have a corresponding inclination towards the centre. Then, supposing the wheel-tread of the rails was made perfectly flat, as was the case in the early rails; when the wheels were in a state of rest and centrical between the rails, they would bear at once on the whole width of such flat-topped rails, with a clearance of half an inch between the rail and wheel flange on each side. But when the train is set in motion the wheels no longer run centrically between the rails, any irregularity in the rail surface or of the propelling power, or in the centricity of the load, causes an oscillation within the limits of the clearance, and the motion of the train is really serpentine instead of rectilinear. Under the influence of such side lurches each wheel is pressed out of its centrical position till its flange approaches the edge of the rail, rises, owing to its conical form, and runs upon its greatest diameter, while the opposite wheel draws away from its rail and runs upon its smallest diameter, until a *reactus reactum* is induced in the opposite direction. The axis of the wheel is thus never horizontal for a moment together

RANMORE CHURCH, NEAR DORKING, SURREY.

A new church for the parish of Ranmore, near Dorking, was consecrated on the 1st ult. It completes the group of buildings which have been in hand some time, and which includes a new parsonage-house and commodious schools. The site is an elevated one, being close to the noble mansion of George Cubitt, Esq., at Denbies; and it is owing to the liberality of that gentleman that the very beautiful structure now referred to has been erected.

The plan of the church is cruciform; a well-developed chancel extending eastward to the same levels of ridge and eaves as the nave, while the north and south transepts observe a like conformity but at a slightly lower range. On the north side of the chancel is the vestry, contiguous to which is the organ chamber, whose openings are partly towards the chancel and partly towards the transept. A handsome stone porch occupies the extreme west of the south wall. There are no aisles to any part of the building, and the roofs are consequently all of one span. The nave and transept roofs are of pitch pine,—the material being so selected as to be without a knot; the chancel roof is of teak, varnished. The walling is externally of unbroken flints, with quoins and bands of Box ground-stone: internally, the whole surfaces are ashlared, in some parts of which fire-stone is introduced to relieve the monotony. The pulpit is octagonal, carved with medallions of the evangelists, and foliated enrichments It is constructed of several materials, including red Mansfield stone, granite, Irish marble, Emperor's-red, &c The font is of noble proportions, and formed out of the richest serpentine marble. The alms box which adjoins is handsomely carved out of solid chesnut. The seats of the church are plain open benches, of oak; those in the chancel being richly designed and executed in the choicest wainscot. The reredos at the east end of the chancel occupies the whole width of the wall, and is of most eleborate design, worked alabaster with marble shafts to the side arcades which contain the ten commandments, &c The centre portion has a rich diaper ground, studded with medallion busts in alto-relievo, and in the centre is the sacred monogram. The table and communion rails are of oak. There are three windows at the east end, with a quatrefoil vesica added above: all these are filled with stained glass subjects illustrative of biblical events. The jambs of these windows are enriched with clusters of Devonshire marble shafts, which are continued along the side walls as an arcade, giving to the chancel a peculiarly handsome effect.

Besides the situations already mentioned, various marbles have

Digitized by Google

been unsparingly used in other parts of the building, the architect exercising his unrestricted judgment on this as well as other matters, so that the result of the whole produces an effect rarely equalled, even in these days of church building.

The steeple, which forms the most important feature both from within and without, rises from four bold arches at the main intersections of the building, and presents externally an octagonal tower, crowned with a bold parapet, and terminated by a lofty spire, the whole rising to a height of 154 feet from the ground line. The belfry windows are each double lights under a comprising arch, and have separating shafts of red Mansfield stone. The masonry of the spire is regularly jointed, and is in alternate bands of plain and scalloped work. A range of spire lights at the foot is introduced with excellent effect. Internally, the octagonal form is obtained from the square by means of well moulded squinches, and the several stages up to the groining are well defined by the variety in their treatment. In effecting this, colour is again brought into requisition, particularly by the use of granite and marble shafts in the different arcades. From the upper row springs the groining, of which the filling-in spaces are in alternate courses of fire-stone and "clunch," producing an agreeable diversity of colour. The introduction of coloured glass in this lantern is also serviceable in imparting a glowing tone to the more ordinary hue of the walls.

Although accommodation is not provided for more than 200 persons, and the building by no means large, as no expense has been spared in rendering everything perfect and of the most suitable kind, the cost has necessarily been considerable. The design and general direction of the whole was entrusted to Mr. G. G. Scott, of London, and the various details have been for the most part prepared on Messrs. Cubitt's premises at Thames Bank, under the superintendence of the principal manager of the establishment, Mr. G. Dines. The carving (both wood and stone) was executed by Mr. W. Farmer, and his assistant Mr. Brindley; the marbles were supplied by Mr. Field, of Parliament-street; the stained glass by Mr. J. G. Crace; the paving by Messrs. Minton; the organ by Mr. Walker; and the peal of eight bells by Messrs. Mears.

A handsome lich gate of teak, substantially framed, forms an appropriate entrance to the churchyard.

THE NEW FOREIGN OFFICE QUESTION.

Since the penning of the remarks on this subject contained in our number for August last, three circumstances especially noticeable have occurred in connection with it:—1. A deputation of some thirty or forty members of parliament to express the wish of a larger body that Mr. Scott's design should receive at least continued consideration;—2. A discussion of the subject in parliament;—and 3. A deputation of some twenty architects to Lord Palmerston to encourage him in his endeavours to overthrow the decision of his predecessors. The first is just that proceeding which, fully carried out, would doubtless in the end result in the most complete disposal of the objections against the practical fitness of the Gothic style to present wants and purposes, in the hands of a competent artist, such as Mr. Scott has on many occasions proved himself to be, that either that gentleman or its other favourers could desire. From the crucible of due and unprejudiced consideration there can be no fear but that Gothic, properly so viewed, would come forth with a brightness not to be deadened or outshone by comparison with its rival Classic, in this instance so strongly urged for by some, and unhurt by the sweeping terms of reproach which from want of the admission of proper thought and examination into the question upon its merits, have been bestowed upon it by those whose education and line of study have been directed more particularly to another style. We are all creatures to a large extent of education, early introduction, and habit, and the impressions made on the ductibility of our youth are not readily, and without real effort or unanswerable argument and conviction, erased in after years. It is not every mind that at once embraces the why and wherefore of a received impression, and on this ground alone it is not to be permitted, though natural, that we should hold by conclusions which may be, and often are, capable of refutation on a more careful and extended reference to the subject. The practical gist of the question, as between Classic and Gothic, of the style to be adopted in the new Foreign Office, is the great fitness and applicability or not of the former for the purposes required. Now the Government Committee of Inquiry reported that the two styles as adapted in the premiated designs numbered 1 and 2, were "perfectly equal in the advantages they offered," and virtually pronounced, as we have before mentioned, the two designs to be "equal the one to the other." On the footing of greater suitability then, Classic has no advantage over Gothic, and this being conceded, and proceedings decided and taken thereon, the former may be fairly considered to be out of court, and the matter as between the two styles at an end. As, however, it may be objected by some that this Government Committee, sufficiently well chosen as it may appear to others, could hardly, in their estimation, have the necessary amount of knowledge either practical or professional to form an opinion, which given, should be accepted in answer to or taken as a veto by all, we heartily join in the request of the deputation first named, that the designs of Mr. Scott should receive "continued consideration"

On the second point, the discussion of the subject in parliament, we would say in the words of one who did a great deal for another cause by the advocacy and practice of such proceeding, "Agitate! agitate!"—and where so fitting as in the modern "Wittenagemot" of the nation. Gothic architecture need not shun or dread the ordeal. Independently of this and how much soever her supporters are aware of it, still, the subject is a national and a public one, and the general public have to be taught and in one sense directed upon it, necessarily in many cases from limited opportunity of acquiring the requisite information as well as engagement in other pursuits; and have also a right to be satisfied, since the main consideration that the payment is to come from their pockets, that the new foreign office when built shall be, both in style and convenience, such as shall fulfil the particular purposes and requirements of the case, redound to the credit of architectural art, and establish the correct taste and advanced state of intelligence of the country.

With respect to the third point, on which much comment has been made and much unpleasant feeling excited, we are inclined to agree with the words of Mr. Horner in his opening address to the Liverpool Architectural Society, "that the expression of an honest conviction in the manner in this case adopted is not open to serious objection," since, as he continues "having reference to a question of really national moment, the private is lost sight of in the public bearing of the proceeding." Mr. Scott and many advocates of the style he adopts have a strong feeling, all earnest minds have, and it applies in both the present directions and all others in favour of it, to the exclusion of that pressed for by the Classic admirers, and they would doubtless claim the liberty of expressing an equally honest conviction of their view on similar grounds, without laying themselves open to the imputation of personal motives. It is not therefore to be presumed hastily that others do not possess the same right sentiment in such matters as we ourselves would desire to be allowed credit for under parallel circumstances, and for which the high standing and character of the members of the deputation referred to should be a sufficient guarantee.

EXPERIMENTS ON THE STRENGTH OF CAST-IRON GIRDERS.*

By James G. Lynde, M. Inst. C.E.

The beams experimented on were eighty-nine in number, and were cast by Mr. Mabon at the Ardwick Iron Works, Manchester, from iron of the following descriptions:—

One charge of the cupola consisted of

12 cwt. Goldendale, Staffordshire.
12 „ Lane End, „
12 „ Ormesby, Yorkshire.
12 „ Blair, Scotch.
12 „ Calder „
All No. 3 hot-blast iron.
12 cwt. scrap.

The beams were cast on their sides, and were a very good sample of workmanship.

The section of each beam was of the form recommended by Prof. Hodgkinson, and upon which his formulæ were based; the total depth of the beam in the centre was 24¼ inches, and at the ends 20 inches; the bottom flange was 15 inches wide, and 2¼ inches thick; the vertical part of the beam was 1½ inch thick; and the top flange was 4⅛ inches wide, and 1½ inch thick; the total length of the beam was 34 ft. 6 in., and the distance

* Abstract of a paper read before the Lit. and Phil. Society, Manchester.

Digitized by Google

between the supports was 30 ft. 9 in.; the weight of the beam was 3 tons 8 cwt. 1 qr.

One of the beams was tested up to the breaking weight with the following results:—

	tons.	cwt.		inch
With a load in the centre of	31	8	the deflection was	·87
,, ,,	42	16	,,	2·00
,, ,,	46	12	,,	2·25
,, ,,	50	8	,,	2·56
,, ,,	54	4	,,	2·70
,, ,,	58	0	the beam broke,	

the ends springing back from each other 2 ft. 3 in.; the fracture indicating a good sound casting.

There was no permanent set observable in any of the experiments until the breaking weight was applied, the beam being allowed to recover itself on the removal of the load in each case.

Each of the remaining beams was tested with a load of 20 tons in the centre, the deflection varying from $\frac{3}{8}$ths to $\frac{7}{8}$ths of an inch.

The calculations for the strength were based on the following formulæ, given by Prof. Hodgkinson in his 'Experimental Researches on the Strength and Properties of Cast-Iron':—

First formula, art. 146:

Let W = the breaking weight in tons placed on the centre of the beam,

a = the area of the bottom flange in inches,

d = the total depth of the beam in inches,

l = the length between the supports in feet;

then $W = \frac{2{\cdot}166\, a\, d}{l}$

In this case $a = 36$, $d = 24{\cdot}25$, $l = 30{\cdot}75$, which gives 60·09 tons as the breaking weight of the beam.

The second formula, art. 147, takes into account the thickness of the vertical part of the beam, and is as follows:—

Let W = the breaking weight in tons placed on the centre of the beam,

l = the length between the supports in feet,

b = the breadth of the bottom flange in inches,

b' = the thickness of the vertical part in inches,

d = the whole depth in inches,

d' = the depth from the top of the beam to the upper side of the bottom flange in inches;

then $W = \frac{2}{3\, d\, l}\left(b\, d^3 - (b-b')\, d'^3\right)$

In this case $l = 30{\cdot}75$, $b = 15$, $b' = 1{\cdot}5$, $d = 24{\cdot}25$, $d' = 22{\cdot}03$, which gives 62·19 tons as the breaking weight of the beam.

The actual breaking weight being 58 tons, it would appear that the constant coefficient assumed is in each instance too high for the quality of iron of which these beams were cast. This result appears to have been anticipated by Prof. Hodgkinson in the case of large beams; and in one of his experiments, art. 147, on a beam cast for Messrs. Marshall and Co., of Leeds, he gives ·625 as the coefficient, which agrees with the result of this experiment.

Applying this coefficient to Prof. Hodgkinson's formulæ, they will be as follows:—

$$\text{First formula, } W = \frac{2{\cdot}05\, a\, d}{l}$$

$$\text{Second formula, } W = \frac{{\cdot}625}{d\, l}\left(b\, d^3 - (b-b')\, d'^3\right)$$

The first of these would give 58·2 tons, and the second 58·31 tons, as the breaking weight; either of which calculations would be sufficiently correct for any practical purpose.

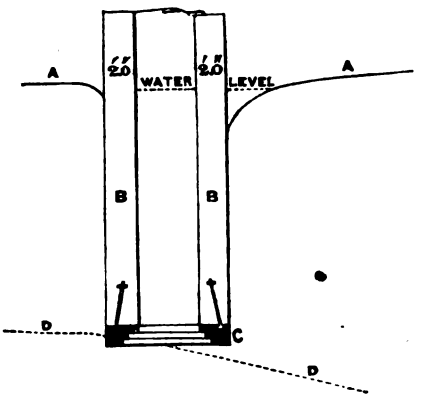
UNDER-SUNK FOUNDATIONS.

By C. J. Spencer.

(*Continued from page* 305).

In sinking one of the trial wells in the bed of the Jurgoo, with a view of discovering the nature of the bottom, it was found that after the well had been got down about 18 feet, it became impossible to move it any further; large quantities of sand were taken out daily, with no visible effect beyond the formation of a deep hole in the bed of the river outside the well; it was evident that the sand came in through a hole under the curb as fast as we pulled it out. It was impossible to lower the water, and the trial well had to be abandoned. The probable reason was that the curb was partly resting on an inclined bed of clay, such as often occurs in the bottoms of nullahs and rivers subject to currents of variable velocities, and that a space was left between the curb and the lower side of the bed of clay through which the sand and water came in, the curb used in this case was partly flat (see Fig. 1), and could not cut its way for any depth into the clay.

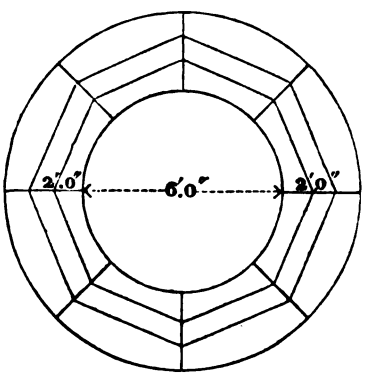
Fig. 1.



Section of Trial Well.
A. Surface of sand. B. Rubble steining.
C. Wooden curb, 18 inches thick, spiked together with iron nails and bolted to steining.
D. Surface of hard clay.

The remedy was obviously to make a curb with a sharp edge, so that every part would sink more or less into the clay, and enable us to pump the well dry, and get out the hard material by hand. This plan was adopted in all the Jurgoo foundation wells, and though they were often hard to move, yet none of them ever got irretrievably stuck. The annexed figures show the description of curb used (Figs. 2 and 3).

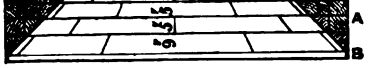
Fig. 2.



Plan of Upper Side.

Besides the advantage of making the well staunch, this kind of curb makes it easier to get at the stuff under the steining, and lessens the quantity of outer material which gets drawn in; it is

Fig. 3.



Vertical Section.
A. Planks breaking joint and spiked together with wooden treenails.
B. Tire of boiler-plate, 6 inches by ¾-inch, projecting 2 inches below curb.

in less danger of catching on stones or other obstacles than a broader surface would be, and the strong iron tire enables it to cut or break through small snags or stones, which would otherwise be serious impediments.

The next difficulty in well sinking is less easy to surmount. I have alluded above to the quantity of outer material which gets drawn in under the curb in the process of sinking; this is in most cases sufficient to cause a depression in the surface of the sand round the outside of the well, which thus gets surrounded by a pool of water. So long as a well stands above this, action is tolerably uniform, but when two or more wells are grouped together, the small quantity of sand between them soon gets loosened and cleared out, the adjacent sides of two curbs have a tendency to drop quicker than the outer sides, the pressure of

Digitized by Google

sand outside the group of wells is greater than the pressure between them, and the well heads all draw closer together, the outer cutting edge of the curb gets a *set* into the outer sand or clay, and the bottoms of the wells turn outwards, and get wider and wider apart, until a rope will no longer hang clear in them; at the same time the heads draw together till the masonry touches, and unless the wells thus brought into contact can be made to sink uniformly, they will soon tear each other to pieces. This spreading at the feet occurred more or less in all the Jurgoo piers, and would have made it almost impossible to have carried the wells much deeper. A partial remedy for this would be to put the wells further apart, but this would greatly increase the difficulty of covering them, so as to make a solid platform for building the pier. Another plan, when there is time to carry it out, would be to sink one row of wells at a time. This is mostly applicable to large bridges, where all materials for starting the whole of the wells cannot be prepared in one season, in which case there is as much time gained in sinking two half sets as one whole set of wells.

There can be no doubt that this spreading at the foot is partly due to the sharp edge of the curb, which gives the foot of the well a lead towards the side where the stuff is hardest, but the sharp-edged curb has such great advantages in other respects that I should be very unwilling to give it up. On the other hand, it is not proved that the flat curb would entirely obviate the evil, but it has been adopted for the Jumna wells, and will soon have been sufficiently tested.

The best shape for the wells is scarcely now a matter of doubt. The one important question,—what will sink easiest, evidently points to a round well. Others are easier to build: in a square well there is a great saving of timber in the curb, but as far as I have been able to learn, experience is against them. The jham, or whatever instrument is used, clears out the stuff from the centre and makes a hollow cone, the base of which extends beyond the sides of the square, but not so far as the corners: the consequence is, that the well or block rests on its corners, while the outer stuff comes in under the sides, and all attempts to sink any further are in vain. I have seen square blocks used at the Shergottee river, on the Grand Trunk Road crossing; there were two for each pier, and each block was divided into four compartments, in each of which a jham was worked. I am not aware of the result of these operations, but the Lelagun bridge, which seems to have been built on the same principle, shows unmistakeable signs of shallow foundations. The up-stream blocks were all undermined by a heavy hill flood, and the whole bridge was cloven from end to end, through piers, arches and roadway, as if some giant had split it with an axe. An engineer in charge of this kind of work ought to be on his guard not to allow his judgment to be influenced by his impatience; if a well or block will not sink after long efforts to make it, there arises a tendency in the mind of the person in charge to think it has sunk deep enough, and build on it accordingly.

It is impossible to take too much care in the construction of foundation wells, especially the lower part of them. They should be of the very best material, brick-work, or other masonry that can be got, and the curb should be firmly tied to the masonry so that it cannot slip or drop away from it; in short, the well should be made as nearly as possible a rigid tube, which may be moved altogether, but which can neither be bent nor broken by the heavy and unequal strains to which it is constantly subjected during its descent.

A correspondent of the *Engineer's Journal* writes—

"I believe that well sinking is a description of foundation which is objectionable on account of the impossibility of quick execution, although it is recommended by simplicity of operation and the absence of need for expensive plant and materials or machinery. The difficulty in India of obtaining means of transport prevents cast-iron from being used in any considerable quantities, and would probably practically preclude the use of cast-iron cylinders with internal joints, in lieu of the present brick wells; but I think that a cast-iron drum might be used in place of the present wooden curb with great advantage. The drum should be of the same external diameter as the proposed well, and as deep as it can be cast; the lower edge should be chisel-faced, and the top should carry an internal ledge, strongly bracketed, to receive the brickwork. The great difficulty in sinking with a wooden curb is the difficulty of undermining the sides, but with a cast-iron drum there is no undermining required, and you have only to excavate in the middle, and the drum in descending will push the earth from the sides towards the centre. When you arrive at the prescribed level or stratum determined upon for a foundation, put any available weights on the top of the well, and when the cylinder ceases to settle let down some good hydraulic concrete in bags (mixed dry) till you get above the water, and then fill up solid brickwork. In case the water cannot be got rid of, the well may be entirely filled with concrete. If cast-iron cylinders are used instead of brickwork for the whole depth, the proceeding is very simple. The cylinders must have their ends turned true in a lathe, must be bolted together by means of internal flanges, the flanges having a sufficient space between them to admit of a packing of 'rust.' The cylinders being by these means rendered water-tight, there is never more water (from the bottom only) than can be easily raised. But the great advantage of a cast-iron cylinder is, that piers of brickwork (when girders are used) are unnecessary, as the cylinder can be carried up to any height to receive the girder. Mr. Spencer (the author of the paper on 'Under-sunk Foundations') objects to a bridge standing on 'naked sticks,' but I cannot see why, provided it does stand; and if this objection can be got rid of, I do not see why cast-iron screw piles should not be used. I have heard of a screw pile being driven through 50 feet of alluvial deposit in as many hours. The only objection I see to cast-iron piers is the occurrence of a top piece of indefinite height, to bring them to the required level; this can only be ascertained after the piers are sunk, and generally requires the pattern to be altered for each one."

COTTAGES AT PARNDON, NEAR HARLOW, ESSEX.

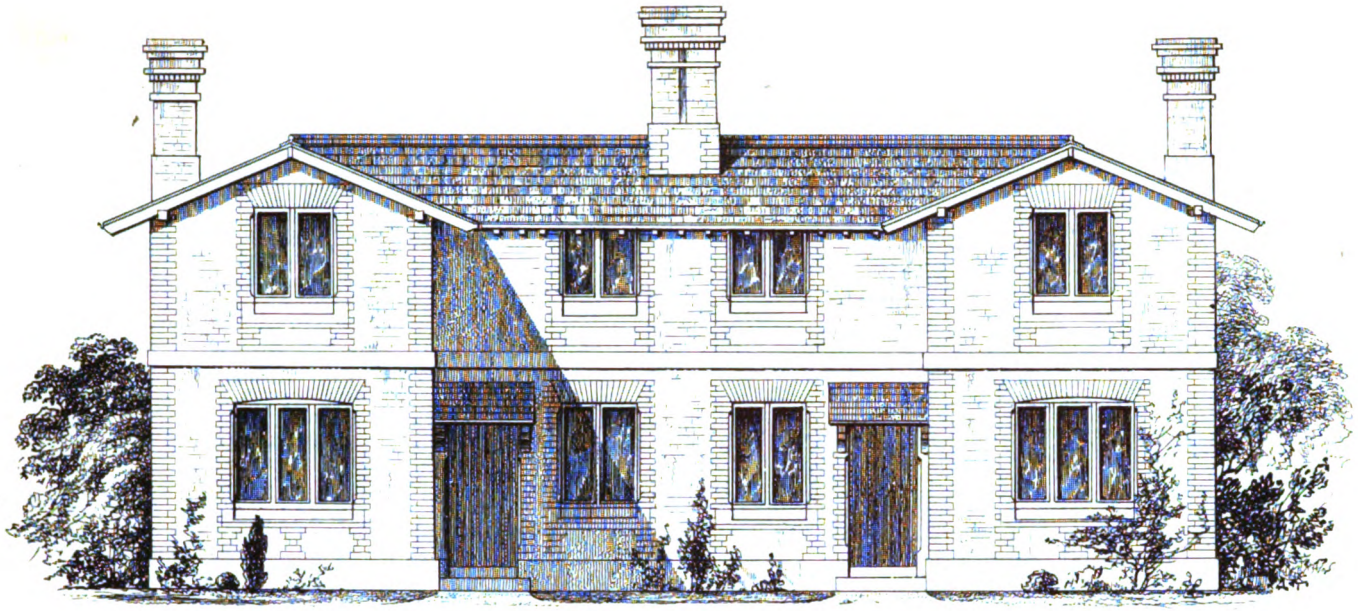
(*With an Engraving.*)

The erection of cottages for the labouring classes has occupied considerable attention of late in the minds of all who have the well being of that large proportion of our population at heart, and the desire to induce a love of home, so much encouraged by a well arranged and comfortable cottage, promoting cleanliness and neatness. Mr. Roberts, in a paper which he read before the Institute of British Architects in 1850, says, "whether we regard (the erection of labourers' dwellings in agricultural and country districts) it in its moral or social relations, in its bearing on national stability or prosperity, or even in the infinitely less important, though more artistic light in which it may be viewed as associated with the attractive charms of English landscape, much might be said;" and again, "that fitness of style, justness of proportion, and internal comfort, are perfectly consistent with picturesque effect, and with that strict economy of construction which is indispensable in cottage architecture adapted for the masses of the people." Speaking also on this subject to the Royal Agricultural Society, the Duke of Bedford most justly says: "to improve the dwellings of the labouring class, and afford them the means of greater cleanliness, health, and comfort in their own home; to extend education, and thus raise the social and moral habits of those most valuable members of the community, are among the first duties, and ought to be among the truest pleasures, of every landlord."

With this view we have selected for illustration the plans and elevations of some cottages recently erected by Captain Slark on his estate at Parndon, near Harlow, fronting the Eastern Counties Railway, a short distance on the London side of Burnt Mill station; as showing that well arranged and comfortable cottages not destitute of a pleasing exterior can be erected at a moderate cost, and thus be in reality sound and good investments for capital. Each cottage has a living-room, large pantry, scullery, coal-cellar, &c.; and above are three bedrooms, each entered direct from the landing, with a fireplace in each room. The cottages are arranged in pairs, and built with Cambridge patent white brick walls, having red brick dressings to angles, doors, windows and chimney stacks. The roof projects considerably all round, and especially in front: this gives to the cottages a much more pleasing effect in perspective than is shown by a geometrical front. The timbers where visible are wrought and stained.

The cost of the six cottages complete (exclusive of grates) was £507 10*s.* or £84 11*s.* 6*d.* per cottage. The whole has been carried out by Mr. Bull, builder, Harlow, from the designs and under the superintendence of Mr. Charles H. Cooke, architect, 11, John-street, Bedford-row.

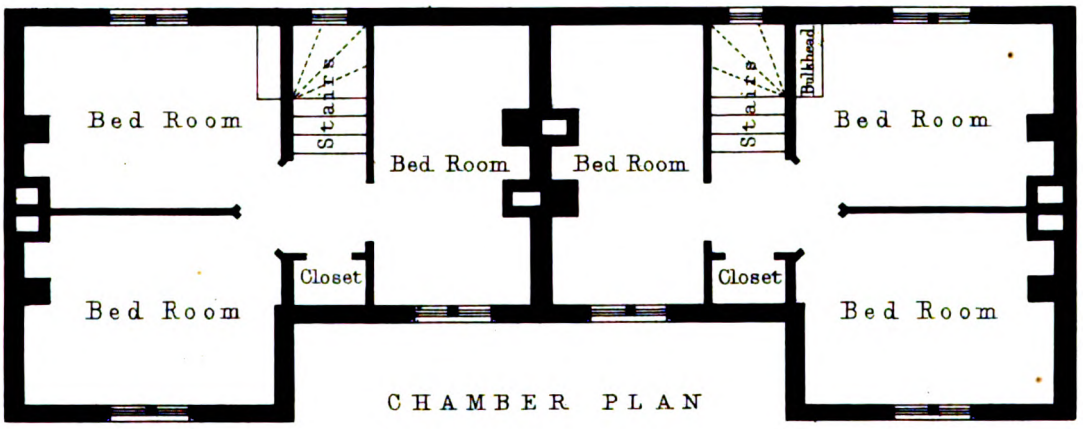
Digitized by Google

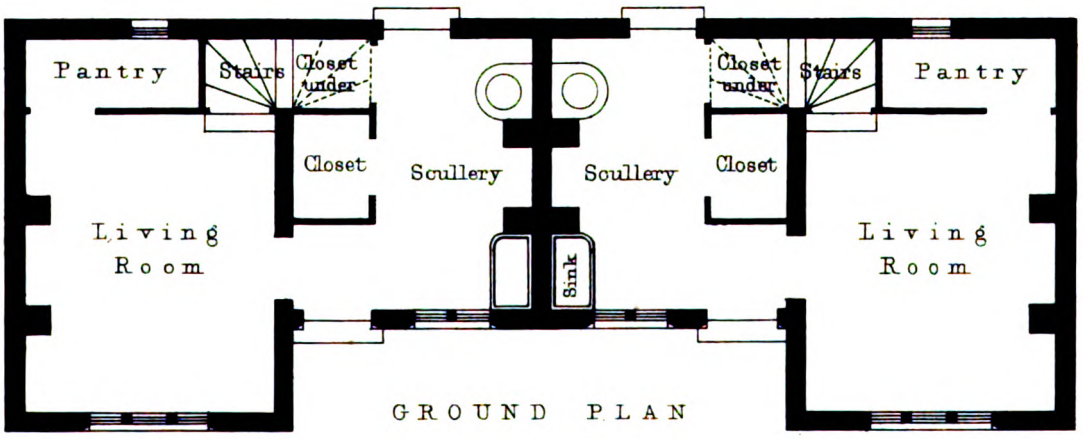


Elevation.

COTTAGES AT PARNDON, ESSEX.

C. H. COOKE, ARCHT





0 5 10 20 30 FT.

Decr 1859

J.R.Jobbins

Digitized by Google

Digitized by Google

ON THE PROGRESS AND PRESENT STATE OF ARCHITECTURE, AND ITS FUTURE PROSPECTS.

By W. Tite, M.P.*

I have been requested on the present occasion, which I consider one of the most auspicious in the history of the Institute of British Architects, to deliver the opening address.

I have said that the occasion is auspicious. And it is so, because we meet for the first time in apartments of extent and convenience, adapted to our wants, worthy of our position in the world of art, and in a certain sense our own. This very desirable result has been brought about by the exertions and liberality of many of our members. After much labour and many exertions, we may at length congratulate ourselves on being "suitably lodged;" and that difficulty overcome, we may now steadily prosecute our professed object of promoting the improvement of our noble art with all convenient accommodation, and without any necessity for future change or further consideration.

Under these circumstances I have been asked to address you. I was unwilling at first to undertake this duty for many reasons: the main one however being, that I could not but feel that there were many men amongst my colleagues younger, less employed than myself, and more able to discuss the topics which will naturally occur on an occasion like the present. As however my professional career has nearly ended, and as my experience has been derived from a period now dating back nearly forty years, I considered that I ought not to shrink from the acceptance of so honourable a proposal, and to do my best to do justice to it, because from the one circumstance I could speak with the greater freedom; and from the other I might still be able to produce something that may be useful in the promotion of an art to which I am so much attached, and to which I am so much indebted. Having said thus much, I come at once to the consideration of the subjects which I have announced as the matter of the discourse, namely, the Progress and Present State of Architecture, and its Future Prospects; or in other words, to consider what has been doing in England and in Europe in this particular art since the Institute was founded, and what we are likely to do hereafter.

In examining these questions, I must bespeak both your patience and forbearance,—your patience, because the subject is so extensive that notwithstanding every possible condensation I must necessarily occupy a good deal of your time; and also your forbearance, because I may have occasion to say things that may not be equally agreeable to all. On the latter point, however, I need hardly assure you, that it is the furthest from my intention to promote hostility by any unkindness, or to presume at all dictatorially on my experience in my own profession.

With these views, let me say, then, that I propose in this address to state very shortly the history of the Institute, to notice what has been done in England and on the continent within about the period limited by its existence; to notice some of the most recent criticisms; and then to add a few remarks on what we may expect will be done hereafter. If in this wide review I should become discursive, you must pardon me for the disorder, since the crowd of objects and considerations which open and press forward upon the mind of any man when he sits down to think or to write on his own favourite pursuit, render it extremely difficult for him to keep within very narrow limits.

I.—First, then, as to the history of this Institute. The Royal Institute of British Architects may be really considered to have originated at a small meeting of architects held at the Craven-hotel, on February 3rd, 1834; when Messrs. Donaldson, Fowler, Rose, Kendall, and some junior members were present, and a committee was appointed to take the measures necessary for the formation of a society to be called "The Institution of British Architects." Many leading architects having approved of the plan, further meetings were held at the Thatched-house Tavern; a printed address and regulations were issued, and the society was duly constituted. In November, Messrs. Donaldson and Goldicutt were elected secretaries, and a council was appointed consisting of Messrs. Robinson, Gwilt, and Kay, as vice-presidents; and Messrs. Barry, Basevi, Burton, Fowler, Kendall, Papworth, as ordinary members. So long ago as the year 1835 our president accepted that office, and during the number of years which have since passed the Institute has to recognise and acknowledge their many and great obligations to him. In 1837 a charter of incorporation was obtained, and in that charter the present title of the Institute was recognised as "The Institute of British Architects." In 1836 the first medal, the Soane medallion, was given to Mr. Godwin, and in the same year appeared Part I. of the 'Transactions' of the society. In 1837 Her Majesty the Queen became our patroness, and in 1847 she placed at the disposal of the Institute annually a gold medal, to be presented to any architect of this or any other country who has distinguished himself by his works or his writings. I am happy to add the first of these medals was awarded in 1848 to the most distinguished and learned architect of this or any other country, Prof. Cockerell. It is impossible, however, to close this chapter in the history of our Institute without referring to another society which started into existence with the same objects, but in point of time a little earlier than our foundation, I mean the Architectural Society. Its origin was due more to the exertions and wants of the younger members of the profession; and in these points it was certainly successful. The patronage was accepted by the Duke of Sussex, and it had a council, vice-presidents, and officers similar to those of the other society. It collected a valuable library and a museum of some extent; and was altogether of great value in the nascent stage of these institutions. The regulations were in some degree more liberal than those of the Institute; and, as I have said, it particularly devoted its attention to the instruction of the younger members of the profession. The first president was the well-known architect Mr. Clarke. In 1838 I was elected president of that society, and presided at the opening meeting in November of that year.

The two societies worked harmoniously together; and it appears by a paper read by myself at the last soirée of the season of 1839, that they were then working together in the much-vexed question even of the present time—public competitions. The principal object of their exertions seems to have been to obtain a fair and intelligible series of instructions for the public competition for the Royal Exchange, then just announced.

Soon after I became the president of the Architectural Society, it appeared to me extremely undesirable in a profession numbering comparatively so few members, that two societies with nearly the same objects should exist; and in 1841 I proposed to the Duke of Sussex to unite the two societies in one body. His Royal Highness, encouraged by Earl de Grey, abandoning his own position, promoted this object by every means in his power, and in 1842 the Architectural Society was united to the Institute.

In closing this account it may be convenient to state that in 1834, at the origin of the Institute, there were 25 Fellows only; that in 1842, after the fusion of the two societies, there were 102 Fellows and 86 Associates; and at the present moment there are 154 Fellows and 139 Associates.

II.—In considering the objects which I have proposed to myself to include in this address, the interval I have thus referred to may be considered to extend over a period of nearly twenty-five years. It is precisely twenty years, almost to a day, since I delivered my first address as president of the Architectural Society. At that time the profession was certainly becoming possessed of a vast amount of historical facts, but I perceive from that paper that I complained of the want of books of judicious criticism.

In Greek architecture, Stuart published the first volume of his 'Athens' in 1762, and the third followed in 1794. The first volume of the 'Ionian Antiquities,' issued by the Dilettanti Society, appeared in 1769, and the second in 1797. The works of Palladio, by Leoni, were indeed published as early as 1715, and Adams's 'Spalatro' in 1754. The 'Elements of Architecture,' by Sir Robert Chambers, appeared in 1759; and he was building Somerset House in 1774. Ancient Rome had been measured and examined by Desgodetz in 1782; and in the present century we have Taylor and Crecy's 'Roman Architecture,' and other works of great value of a similar kind in French and German. The first edition of Durand's 'Parallel' is dated in the year IX. of the French Republic, or 1800. With regard to the so-called Gothic architecture, Carter commenced his 'Ancient Architecture' in 1795; Britton produced the first volume of his 'Architectural Antiquities of Great Britain' in 1806, and he commenced his 'Cathedrals' in 1816.

From the books thus enumerated—of course continuing the Gothic series down to the period to which I am speaking—a sufficient amount of information on all the leading styles might be

* Address delivered at the opening meeting, Session 1859-60, of the Royal Institute of British Architects.

Digitized by Google

obtained. The architecture of Greece, which has been so skilfully copied and adapted in our own time by Sir Robert Smirke in the late Covent-garden Theatre, the present Post Office, and other public buildings, was gradually growing out of fashion. Roman architecture, in the modification commonly called "Italian," derived from the works of Palladio and the architects of the Italian school, doubtless promoted in England by the greater works of Inigo Jones and Wren, was superseding the plainer forms and decorations of Grecian architecture.

The study of Gothic architecture, perhaps mainly promoted or incited by the movement in the English church known under the name of Tractarianism or Puseyism, had become common, not only amongst architects, but distinguished members of both Universities.

The Cambridge Camden Society, with its motto "Donec Templa refeceris," was established in November 1841, and published the first volume of the 'Ecclesiologist' in 1842. In Oxford the movement was somewhat later; but it burnt, and still continues to burn, with greater intensity. The Camden Society of Cambridge having met with discountenance in high places in the University, from the retirement of several of its episcopal patrons, and the chancellor and vice-chancellor, was given up in May 1845.—These considerations being premised, I propose now to give you a slight *Review of the Progress of Architecture in Europe.*

III.—In such an important retrospect, France must have the first place. Her architects are the most accomplished and the most carefully taught; the patronage of the government is enormous; and the movement in a lower sphere is even greater than it is in our enterprising nation. What are they doing then? becomes a very natural question, but to answer it requires almost a volume rather than an address. I must request you to forgive me, if I go somewhat largely into a criticism on French architecture and French taste; because much that I may say therein will apply to England, without the offensiveness which might belong to a criticism of the works of my immediate contemporaries at home.

At the fall of the first Napoleon, and during the period of the Restoration, the architecture of France was modelled, as with us, on a close study of the Roman Imperial grandeur; and also on the examples of the Palatial architecture of the Scamozzi and Vignola schools. The pure Grecian style never was cordially adopted by our neighbours; though unquestionably the building materials which they had at their disposal were more fitted for its execution, than were the very incongruous brick and cement which we in England are obliged to employ. There were, however, some very valuable illustrated architectural works published by the French government of this period; and amongst others the description of the results obtained by the Scientific Expedition to the Morea, which might have been expected to have directed the attention of architects to the beauties of Grecian art; and the publication of the great work upon Egypt, as compiled by the Institute of Cairo, together with that of Denon of the same mysterious country, were all of a nature well calculated to revive the study of the æsthetical principles adopted by the great prototypes of our civilisation. But it is remarkable that, unless the monumental character of the Abattoirs, or the peculiar tone of the design of the Chapelle Expiatoire, by MM. Percier and Fontaine, be considered to have been the results of the study of Egyptian art, there was really very little to be found in the edifices of this period to indicate that the French architects were disposed to shake off the traditions of the school of Vignola; since the Egyptian elevation, given by Navier to the unfortunate Pont des Invalides, was too isolated an effort to be considered otherwise than as an exception to the general rule. The Chapel of the Cemetery of the Père la Chaise; the completion of the Bourse, of the Chamber of Deputies, and of the Halle aux Blés; the Church of Nôtre Dame de Lorette; the Theatres of the Vaudeville, Ventadour, Ambigù-Comique; the Passages des Panoramas, Vivienne Vero-Dodat, Colbert, Choiseul, &c., in Paris; and in the departments, the Custom-house of Rouen, the Theatre of Nantes, the Palais de Justice of Caen, the votive Chapel of Rosny, &c., were all designed in the bold, manly, but somewhat mannered and affected style, which might equally be discovered in the productions of the contemporaneous painters Gros, Gérard, Blondel, Meynier, Abel De Pujol; or in the literature of the day as represented by De Pradt, Lammennais, De Bonald, De Maistre, De Fraysinous, De Chateaubriand, Montlosier, and others.

But whilst this taste prevailed in the official regions, there was silently, but surely, at work the same feeling in favour of the study of indigenous art, and of the history and literature of the middle ages, which in our country had been so wonderfully advanced by Sir Walter Scott. The modern romance school of French literature originally raised its banner about the latter end of the Restoration period; and previous to the period of Victor Hugo, Lamartine, St. Beuve, Delavigne or De Vigny, the exclusive admiration for the Classical school had been shaken by the influence of the writings of such authors as Guizot, Cousin, Royer Collard, Sismondi, Barante, Thierry, and Salvandy, and even by those of Desaugiers and Béranger, Vitet, Mérimée, and their followers. In fact, French society began to emancipate itself from the "eternal Greeks and Romans" of the schools; and equally in literature, so in art, it began earnestly to seek for other, and in many cases better principles. David and Gros went out of fashion, just as Madame de Staël and La Harpe had done; and such noble and natural artists as Paul Delaroche, Horace Vernet, Ingrès, Delacroix, Ary Schœffer, Leopold Robert, and Guericault, introduced an entirely new school of painting, at the very same time that the transfer of the Maison de Francois I., and the restoration of some of the Mediæval buildings which had suffered during the revolutionary storm, began to revive the national interest in its own most copious and interesting archæology. MM. Nicole Xavier Willemin, Dusommerard, Charles Nodier, and Baron Taylor, should especially be mentioned amongst those who laboured successfully in this effort for improvement.

On the accession of Louis Philippe in 1830, it seemed as though the directors of the fine arts of France—for everything amongst our neighbours originates with the government—thought that it was their duty to impress as distinctly marked a line of demarcation as was possible between the external expressions of the civilisations of the period before and after the Revolution of July. The exclusive study of the Classical or of the Mediæval architecture of Italy was abandoned, and the *furors* for the indigenous form of the Renaissance was substituted in its stead. This, however, was to be succeeded at a later period by the worship of the Ogival architecture in all its purity by a small party of French architects, and of the style of Louis XV. by a larger number. Some of the monuments erected in the early portion of Louis Philippe's reign were, however, still influenced by the broader and bolder methods of design which had been previously in fashion; and the Palais du Quai d'Orsay, the Church of St. Vincent de Paul, the Barrière du Trône, may be adduced, in connection with the fountains in the Place de la Concorde, as illustrations of the Classical school. In the attic of the Barrière de l'Etoile, in the restoration of the Hôtel de Ville, in the Ecole des Beaux Arts, in the numerous pavilions of the Champs Elysées, and in other instances, the progress of the taste for the architecture of the Renaissance may be distinctly traced. This particular phase of taste may also be observed to have prevailed to a great extent in the street architecture of the day—as, for example, in the Place St. George, the St. Germains and the Versailles Railway stations, the fountains of St. Sulpice, Molière, and Place Richelieu, the mortuary chapel of the Duc d'Orleans, and elsewhere. Towards the end of Louis Philippe's reign the Mediævalists came still more into notice, and even to such an extent as to afford the subject of some of the best scenes of the remarkable picture of French social life given in the excellent fiction entitled 'Jerome Paturôt à la Recherche d'une Position Sociale.' At that period they certainly did achieve some great and meritorious results by their restoration of the Cathedral of Nôtre Dame and of the Sainte Chapelle at Paris. The Church of St. Clotilde is a curious antiquarian study, and perhaps it may be a very correct revival of French decorated Gothic; but there is so marked a distinction between French and English Mediæval art, that it would hardly be fair for an English architect to pass an opinion on that elaborate production without having devoted considerably longer time to its examination than I have been able to give it. It is however worthy of particular remark, that Gothic architecture, to use a convenient phrase, has never taken any strong hold of the educated or wealthy classes of France, and that even the clergy have treated its revival with far less enthusiasm than might have been expected from what has occurred in our own country. Of course there has been an archæological excitement, and a very careful study of the relics of the middle ages, under the guidance of MM. De Caumont and Viollet le Duc; but it is in vain that we seek in France for anything like the hearty adoption of Mediæval feeling to be discovered in the best specimens of the church architecture or of the domestic edifices produced by some of our

Digitized by Google

English revivalists. Even the restoration of the Church of St. Ouen, commenced in the reign of Louis Philippe, is open to the criticism of being unfaithful to the original; and it may be suspected that the true spirit of the French Mediæval artists has not been really seized upon by their successors.

This fact seems to be more clearly proved by the productions of the French school of architecture during the present imperial *régime*. The Bibliothéque St. Geneviève, the Ecole des Arts et Métiers, the offices of the Crédit Mobilier, the Salles des Ventes des Commissaires-Priseurs, and other public buildings recently erected by the architects of the contemporary school, are executed in a style which may best be described by saying that it is a bad attempt to develope the spirit of the Renaissance. The additions to the Louvre were to some extent regulated by the buildings they were intended to complete; and it has happened, fortunately, that both MM. Visconti and Hittorf had made their reputations before the modern school attained to the dignity of being fashionable. M. Lacornée, the architect of the Hotel du Ministère des Affaires Etrangères, had also acquired the right to express his own belief in the matter of style by his successful treatment of the Palais du Quai d'Orsay; and he was thus enabled to erect the very effective specimen of the modified Italian style above mentioned. The restorations of the basement of the Tower of St. Jâques de la Boucherie, and of the old palace of Catharine de Medicis, have been carried out with scrupulous archæological correctness; but the new buildings around the Church of St. Germain l'Auxerrois are designed in a style which defies classification or description about as much as it provokes criticism. In the new streets which intersect Paris in every direction the taste of the modern school seems to have run riot, and the greater number of the houses have been built in the "bed-post and valance" style, as Mr. J. W. Papworth has very aptly named it. All the formerly received opinions with respect to profilings of mouldings, all those connected with the relief, proper character, or end of ornamentation, have been rejected; the distribution of spaces has been treated as though it were a matter of utter indifference; and, in fact, the architects of the capital especially seem to have considered that their true merit would consist in practically ignoring the results of the studies and experience of their Classical predecessors, and in the attempt to elaborate a new and grotesquely original style of their own. The words "architects of the capital" were designedly adopted in this place; for in the provinces the prevalent bad taste of Paris has not effected so much mischief as might have been expected; and the architecture of the new buildings at Marseilles, Lyons, Lille, and Havre still retains traces of the influence of sound studies. In the capital itself the fashionable architecture of the day seems to me to be as devoid of moral aim, of depth of conviction, or of earnestness, as the society itself in which it arose manifestly appears to be; and there seem to me to be many reasons for seeking the explanation of this great change—as, indeed, of all other great changes in the architectural taste of this, or of any other nation—in the ever-varying phases of its moral life. A nation which could abdicate its liberties as modern France has done, simply because its leading men were incapable of controlling the excesses of domestic factions, was very likely to accept the philosophy of MM. Taine and Caro instead of that of MM. Renan and Simon; to receive with delight the literature of the Cassagnac, or the Alexandre Dumas Fils schools; or to admire the architecture of the Casernes Napoléon, or of so many houses in the Rue de Rivoli, or the Boulevard de Sebastopol. I have given this somewhat elaborate sketch of French architecture, because, as I have said before, without the offence of personal criticism or personal allusion I could refer to the history of architecture during the last twenty years in my own country. The varying phases of taste may be found in much of the same order in our own metropolis; and I could suggest many parallels in the works of my own countrymen. I am satisfied however to be able to add, that in England Gothic architecture has been studied and applied with learning and taste, instead of so devoted an attachment as the French have shown to what would be in our country the architecture of Elizabeth and James the First; and though the architecture of our streets has shewn a tendency to over-ornamentation, still it has never fallen into the platitudes and littleness of the new Parisian thoroughfares.

The phases of the history of architecture in the neighbouring countries to France appear to confirm many of these opinions as to the modifying causes of the external character of the arts of any particular nation. In Belgium, for instance, although the outward form of the civilisation of the capital itself presents but a very pale reflex of some of the vagaries of French taste; and although, on the contrary, the study of the national archæology has been carried on with a rare degree of skill and conscientious appreciation of the merits of the Mediæval arts; yet neither the influence of fashion in the one case, nor, so to speak, of national self-worship in the other, has prevailed so far as to induce the Belgians as a nation to resign their spirit of local independence in all things. It is true that some of the results of this local independence have been far from being æsthetically pleasant; and the new church of the Quartier Léopolde may fairly be cited as a specimen of pastry-cook's architecture, and the Colonne de la Constitution is equally open to criticism. But the Galerie St. Hubert, and the new Rue Léopolde, the new markets, and the railway stations of Bruxelles, the new buildings of Antwerp, Gand, Louvain, Liege, Malines, &c., all alike have their own local character. Indeed it is possible for those who are acquainted with the past history of these provinces to discover even the relics of their former occupants; and in Antwerp and Gand especially, to identify the influence of the Spanish rule in the excessively ornate, misplaced, and heavy style of ornamentation which is still retained. The essential characteristic of the Belgian architecture is, however, that it is almost communal; except in Brussels, and in some of the Walloon towns near the French frontier. But even whilst thus remaining communal, the Belgian architecture of the present day seeks its inspiration rather from Mediæval or modern Italian art, than from its own great artists of the dawn of the Renaissance. The Belgian population is precisely what its priests have chosen to make it; and so it happens that the taste of the beginning of the sixteenth and seventeenth centuries, which more distinctly typify the period of priestly influence, still retains its hold on the passions of the country. The churches most recently built in Belgium are usually of the later Renaissance style,—neither Mediæval nor strictly Classical architecture is received in the country. At present the most decided traces of the existence of such a tendency is to be found in the style of architecture adopted at Gand and at Antwerp; and in this respect those towns offer to the student of architecture a degree of interest (both ancient and modern, be it observed) which the capital cannot boast. The great merit of the best recent Belgian architecture consists in this, namely, that while its authors seem to have remained at peace with the teachings of other times, they still represent the feelings and instincts of the nation in its most vital interests, and its most striking mode of external expression.

Very much of the influence of the same principles may be observed to exist in Holland; for of late years the buildings erected have been marked by the peculiar local tastes and the mixture of reverence for Classical studies which have so long prevailed in the Low Countries. The nature of the foundations, and the very limited range in the choice of building materials at the command of the Dutch architects, no doubt, have exercised considerable influence upon their modes of thought. Perhaps, also, the peculiar political organisation of Holland, which is still in fact a federal republic under a centralised administration, and the singular state of sleepy isolation from the political and intellectual movement of the rest of Europe, which has retarded the material prosperity of the Dutch for so many years, may likewise have influenced the state of its architecture. The climate of Holland has also no doubt operated on the style of its buildings; for a nation which is forcedly prevented from seeking its pleasures out of doors, almost of necessity confines its indulgence of the faculties of taste to its internal comforts. Be this as it may, the Dutch architecture of late years is strikingly devoid of character in its treatment of the exterior of buildings; and the little of novelty which can be discovered in this respect is principally borrowed from the teachings of the Westphalian school. The Zeemanshuis of Amsterdam, the Gasthuis of Rotterdam, the new churches of Rotterdam and Purmerende, and the very contemptible railway station of the Hollandsche Spoorweg at Rotterdam, are illustrations of the Germanic influence; which has also extended to the domestic architecture of the provinces of Friesland and Groningen especially. In the Post Kantoor of Amsterdam, the Clubhouses of the Societies Arti et Amicitiæ of Amsterdam, and the Yacht-club of Rotterdam, the new town of Rotterdam, &c., the French influence has been retained, and very awkward imitations of ashlar construction have been executed by the use of wooden beams, planks, and cement and plaster. Some of the rare Mediæval buildings of Holland have lately been restored, such as the

Digitized by Google

St. Laurent's Kerke, at Rotterdam, the Cathedral of Utrecht, the Tower of St. James's Church at the Hague—though it may be observed, *en passant*, that the latter building can hardly be called Mediæval—and the Nieuve Kerke of Amsterdam. These works, unfortunately, have been conducted with a very slight knowledge of the principles of the architecture of the periods in which they were erected; and they illustrate a fact which is apparent from other considerations—namely, that architectural studies are not conducted in Holland on any very scientifically organised principles. The "other considerations" to which I have referred are principally, that architecture is hardly recognised in Holland as a distinct profession, but is practised indifferently by engineers, builders, or shipbuilders; and, until within a very few years, Holland was utterly devoid of any critical publications on the æsthetical questions of the day. Of late however, M. Alberdingk Thym, and the Amsterdam Society for the Improvement of Architecture, have produced some works which lead us to hope for a revival of the national taste in architecture, and for the abandonment of the awkward imitations of the tastes of other nations which now so offend the educated artist who may travel in Holland.

As to the Westphalian provinces, they have made wonderful strides in all the phases of material civilisation since the peace of 1815, and they have eliminated an æsthetical expression of their innermost thoughts, which must command very serious reflection. The Dusseldorf school of painting, for instance, under Bendemann, Schadow, Hildebrand, Lessing, Sohn, and Achenbach, has earned for itself a foremost place in the annals of its country's history; whilst the architecture called into existence by the amazing development of the commercial and manufacturing industry of this favoured region, has advanced nearly *pari passu*—perhaps, however, with less of a local character, for the influence of the Munich and of the Berlin schools has manifestly been felt at Dusseldorf and Cologne. Throughout Germany, in fact, the attempt to cast off the trammels of Classical, Italian, or French architectural taste has been made with a species of passion; and architects, equally with metaphysicians, poets, romance writers, and politicians, have striven to discover and represent the anatomy of their own nation. The study of German Mediævalism has been conducted with quite as much enthusiasm as the analogous movement in our own country; and Muller, Semper, Rosengarten, and others, have laboured as effectually as our archæologists have done to diffuse a knowledge of the former changes of their favourite art. It has happened, however, that the great impetus given to the commercial and industrial prosperity of the Westphalian provinces produced its effects about the period when the taste for indigenous forms of art had established itself in public estimation; and thus it has also happened that nearly all the new factories and buildings on the banks of the Rhine, or of the Rhur and other affluents of that mighty stream, have been built in a style of architecture which is mainly inspired by the study of the middle ages. It is perhaps worthy of more than casual remark that the phase of Gothic architecture which has been most popular with our German neighbours is the one called by themselves "Romishe Baustyl;" and the majority of the ecclesiastical buildings lately erected in the Westphalian provinces are built in this style. The civil constructions of late years have, however, been designed upon rather more eclectic principles; and the Spitzbogenstyl, as exemplified in the Marienberger Schloss, or the Gurzenich of Cologne, has been applied with considerable skill. It is this peculiar modification of revived Mediæval art which has been imitated in Holland and in Belgium; and it has renewed another of the hidden links of sympathy still existing between the various Low Dutch tribes. Some of the defects even of German detail, as practised by living architects, have been blindly copied by their followers; and the essentially bad taste which induces many who ought to know better to break the lines of pediments or of gables, to insert unmeaning ornaments, has found numerous imitators in both Holland and Belgium; it may be, with the greater readiness, because the former Spanish masters of the Low Countries were themselves exceedingly addicted to this very illogical practice of breaking pediments.

In this division of our review it is necessary to call your particular attention to the manner in which the restoration of the Cathedral of Cologne is being conducted. The original designs have been fortunately preserved; and they are, to the infinite praise of all parties concerned, being strictly adhered to, even whilst the parties employed have eschewed a mere Chinese spirit of imitation. In the restoration of the Church of St. Ouen, at Rouen, the same good taste was not displayed, and consequently the original symbolical design of the west front of that church has been destroyed, together with the beauty of its proportions.

In continuing our notices of the architecture of foreign counties, I fear that Italy must be soon dismissed, except as it regards Savoy, of which I shall say a word hereafter. But of the modern architecture of Italy, the latest example that has come under my notice is the great and costly, but most wretched and feeble, Church of St. Carlo Borromeo in Milan. This is a votive church, which was erected after the first invasion of the cholera, from the designs of an architect named Amati. It is a rotunda like the Pantheon at Rome; apparently also of the same diameter, and generally agreeing with that building in its details. It stands at some slight distance from the Corso, forming the end of a small square, the sides of which are decorated by porticoes, having shops below and three stories of public offices above. Apart from the admirable material used in the construction of this church, the granite of Baveno, there is absolutely nothing to admire in it, or scarcely to approve of. The dome appears externally to be much flattened; and the extent of it is diminished by its being placed at the end of a very narrow atrium. It is a very bad copy of the Pantheon foolishly applied.

In Milan, however, a most successful attempt has been made to revive the manufacture and use of architectural decorations in terra-cotta. As you are aware, constructions in this material were very common in the North of Italy; and in the Certosa of Pavia much of the external decoration is executed in this substance. The cloisters in particular exhibit a remarkable instance of the success and durability of this mode of decoration. In the Corso at Milan, and in one of the great streets leading from the theatre, two architectural elevations of great extent, and in one instance of considerable architectural beauty, have been executed in terra-cotta by Boni and Co. I call your attention to this revival of an ancient and effective material because it appears to me that considerable variety and beauty might be given to the external elevation of many of our own domestic buildings by the introduction of this mode of decoration, which is at once effective, durable, and economical.

I am unable to suggest anything more in connection with the architecture of Italy during the last twenty years, excepting to advert with satisfaction to the archæological and architectural works of our late distinguished correspondent and honorary Fellow, the Commander Canina, though I am not aware of any extensive architectural work executed by that most distinguished and accomplished man. His death, soon after his visit to England, is a circumstance of the deepest regret to all of us, for in him architects and travellers in Italy have lost a generous and accomplished friend and cicerone, and archæology one of its most distinguished and successful students.

I am afraid it is not possible to advert particularly to the architecture of Germany; and this is the less necessary, because it is better known by modern architects than that of most other countries. The perfect illustrations given by the published works of Klenze and Schinckel, and the regular publication of the 'Bau Zeitung' by our Associate, Förster of Vienna, inform us of everything that is going forward in that nation connected with our art. The Germans have succeeded hitherto rather indifferently in Gothic architecture. The church in the superb Au, at Munich, notwithstanding its superb painted glass and its generally satisfactory proportions, is a poor imitation of that style, and the Monumental Cross at Berlin is something worse. The church now being built at Vienna by Ferstal, the Votiv Kirche, will be an excellent specimen of German Gothic, and shows vast improvement in knowledge. Whilst the Evangelische Kirche, which had just been finished when I was last at Vienna, was in a sort of thread-paper Burgundian or Lombardian style of the worst sort.

Before concluding these remarks on the state of architecture in foreign countries, it may be as well to add a few words on what are observed in those which are less frequently visited with the intention of seeking from them lessons in the history of art. Thus, in the Canton of Geneva, and in Savoy, the architecture which has until lately prevailed has been almost the same as that adopted in the South Burgundian provinces of France; but within a few years both the Germanic and the Italian influences have made themselves distinctly felt. In the Piedmontese dominions of the King of Sardinia, as might naturally have been expected, the Italian element has exclusively prevailed; and it is to be observed that it has so prevailed in the form it assumed

Digitized by Google

bout the sixteenth and seventeenth centuries, rather than in the form of the eighteenth. In Turin itself, however, the style of street architecture adopted in the new quarters has been copied from the buildings of the Rue de Rivoli in Paris, without much modification; and the great public works have almost always been designed in the style of the French engineers; as in the case of the bridge over the Dora Riparia, and in the railway works.

In the north of Spain the character of both civil and ecclesiastical architecture has been modified by the very unblending nature of the materials to be there found: granite, and an inferior kind of brick-earth, are alone at command. It must be added that the population, though surrounded by all the natural elements of wealth, is so miserably poor, that there is little call for the display of any artistic excellence. It follows from these circumstances, that architecture as a distinct art does not exist in these provinces now; and as in Holland, builders and engineers have replaced architects to the serious injury of the local taste.

The United States afford greater promise for the future of art than neglected and misgoverned Spain: but very little is known here on the recent development of the arts amongst our Transatlantic brethren. I only propose to call attention to the fact that in the towns of Boston, New York, and Philadelphia, near which both granite and marble of superior quality are raised at comparatively speaking little cost, the style of architecture which seemed to be most generally adopted some twenty years ago was mainly based upon the Grecian Trabeated style. In fact, the clear bright atmosphere of the American climate rendered the purity of line of the Grecian architecture singularly appropriate to surrounding natural conditions; whilst the great transverse strength of the materials, and their somewhat impracticable character, made them peculiarly fitted for the horizontal, and as Mr. Ruskin would probably say, ignoble construction of the Hellenes. The materials which any particular neighbourhood can furnish have indeed a material influence on the style of architecture which may prevail therein; and it is a fact that merits far more attention than it has hitherto received from writers on the history of art.

Now, to revert very briefly to the question raised at the commencement of this part of our subject, I must say that I cannot discover, in the prevalent architectural tastes of the countries I have referred to, any traces of what may be called permanent æsthetical principles. The faith or the fashion of the day is all-powerful, but the morrow may change the whole aspect of the art of architecture; and this must continue to be the case so long as mankind *feel* in these matters, rather than reason upon them!

The simultaneous revival of the study of Mediæval art in all the leading nations of Europe appears to me to be connected with the great political and moral revolution of the first portion of this century. The Renaissance, or the revival of Classical studies, was in fact synchronous with the introduction of the spirit of analytical philosophy, in all the branches of human knowledge, instead of the synthetical principles which had prevailed during the "dark ages," as it was long the fashion to call the previous period. Now the excessive development of the analytical spirit led, through the sensualistic philosophy of the seventeenth century, to the avowed atheism of Helvetius and Condorcet, and to the sneering infidelity of Voltaire and Gibbon, as well as to the wild political theories of Rousseau and the French Humanitarian school. The fearful havoc made by the attempt to carry into effect the theories of these wholesale teachers of doubt in all matters of faith or of social organisation, at the French Revolution, naturally produced a revulsion in men's minds; and society was led, in its utter lassitude from the struggle against all forms of belief, to cast itself without reserve upon the principles of authority which it previously had renounced at so heavy a cost of blood and treasure. With the return to the moral principles of former times, the taste for the characteristic arts of those times also returned; and modern society began even to consider that there was a necessary connection between the archaic expression of the buildings and the hearty belief of the men who erected them: forgetting the while, that unless civilisation be entirely destroyed, the human mind cannot retrace all its steps, and that the revival of extinct phases of art, in their original purity of faith, is utterly impossible. Be this as it may, the revival of the love for Mediæval art coincided with the appearance of the romantic school of literature in England, France, and Germany; and it is to be observed that the success of this movement has been strikingly proportioned in those countries to the intensity of the national feeling that mankind had gone astray from its proper path during the last two or three centuries. Perhaps also the very different manner in which the clergy of Spain, Italy, Belgium, and even France, have participated in this movement, from that observable amongst our own Tractarian clergy, may be attributed to the fact that to the former the semi-classical style of the Renaissance is not so necessarily typical of the revolt from the principles of authority as it is to the latter. There is to the Jesuit, for instance, who contemplates the magnificence, or at least the costliness, of St. Carlo Borromeo at Antwerp, or the Jesuit churches in Turin, Rome, and elsewhere, no necessary connection between the ideas of the Renaissance style of art and the Reformation; whereas in England, the later Tudor and the Jacobite, and the semi-Italian styles of Jones and Wren, are distinctly connected with that great movement. Those who in our country seek to return to the systems and modes of faith of former time, are naturally led also to seek the revival of their forms of art; whilst in the countries wherein Catholicism has always retained its power, those forms have ceased to express to the popular mind any peculiar character of dogma or of faith. The revived admiration of Mediæval art had therefore no meaning in the countries above mentioned, and it seems to me, therefore, to have been equally overlooked by them; thus furnishing a tacit commentary on the theories of those who seek to connect styles of architecture in an absolute manner with forms of faith. The connection of these things is indeed relative, but not absolutely necessary; and that which may be true of one locality or of one epoch will not be true of all.

In the reference which I made to an address delivered by me in 1839, I spoke of the great deficiency of critical books on architecture existing at that time. Since that period, however, a good deal has been done to meet that want, and in considering the progress of architecture during the last twenty years it is impossible to deny the influence of those works on the national taste; but they have acted principally in one direction only. In the last century we had Hogarth and Burke, Alison and Uvedale Price; and their important works laid down many most important principles, and aimed at distinct definitions, but without much success. In the present century we have Hope, Pugin, Fergusson Ruskin, Scott, and others, excelling in description and abounding in technical learning; but still, as it seems to me, bringing no practical result from their learned labours, excepting indeed it be that they have generally joined in an unreasonable and exclusive praise of Gothic architecture as known in England. To this, however, in the series of names now quoted, there is one most important exception in the case of Mr. Fergusson, who in learnedly and ably describing the existing styles, does not give an unreasoning adherence to Gothic architecture, but still pants for some undiscovered excellence, which I fear that life is not long enough to realise.

Of this list of critics I shall first name the very eminent architect whose death we all lament,—the younger Pugin. He not only wrote skilfully, and drew admirably, but he was the best exponent of his own works. I have no doubt that his 'Architectural Contrasts,' though somewhat exaggerated and extravagant, exercised a most important influence at the time they appeared. He, however, was a man with only one idea; he determined to consider that English Gothic—perhaps more distinctly Norman Gothic—architecture was not only the only Christian architecture proper, but the only architecture worth knowing anything at all about. From himself perhaps, more than from his writings, the fashionable terms of "Christian" and "national architecture" appear to have arisen. I may here say a few words on these terms, and so dismiss them.

I cannot understand the fitness of either phrase. How can "Christian architecture" be considered as being confined to those forms of Pointed architecture which grew up and flourished in England in the eleventh, twelfth, and thirteenth centuries? The Italians inquire with truth, "Why is the architecture of those edifices where our martyrs and confessors preached and suffered to be considered not Christian?" And with regard to nationality, when one examines the churches of France, Germany, and even of Spain, in the most elaborate and perfect style of Gothic architecture executed by the architects of those respective countries, why are we to be impertinent enough to proclaim Gothic architecture as essentially national? It surely has been distinctly proved that in France the early forms of Gothic architecture took root long before they were practised in England; and in my judgment, if any nation may have the right to claim Gothic

Digitized by Google

architecture as national it is the French, and not the English, to which it belongs.

Passing from Pugin, who was a professional author, I proceed to notice some of the numerous and very important publications of Mr. Ruskin; but I am not aware that he has ever attempted to carry his opinions or his theories into actual execution. His original publication on the Superiority of Modern Painters to all the Ancient Masters, appeared in 1843; but his first work strictly devoted to architectural criticism, entitled the 'Seven Lamps of Architecture,' was published in 1849.

In choosing Mr. Ruskin's criticisms as the subject of the remarks which I may have to offer, he will allow me to explain that I select him because he is the founder and ablest supporter of the modern romantic school; and that he best represents the class to which I wish to refer. In speaking however of the writings of this gentleman, every reader cannot fail to admit and to admire his varied learning, his imagination, his fancy, and his truthfulness; but at the same time, architects must lament his imperfect knowledge and consequent dogmatism.

As to his criticisms and opinions upon painters and painting, I leave them to painters. But with regard to architecture, I consider it almost a national misfortune that accidental circumstances should have led him to take up his residence in Venice at a time when these studies apparently first attracted his attention. All his opinions appear to me tainted with the influences of that very worst of the forms of Gothic architecture; and though in Venice perhaps the history of Gothic architecture may be more distinctly and more correctly traced in every stage than in any other city, yet I consider that development to have been, excepting in the mere point of foliage, either flimsy or clumsy; and in point of extent and importance comparatively trifling.

The largest, most prominent, and specific example of the Venetian Gothic is the Doge's Palace; a building which, as Mr. Fergusson says, "all the world agreed till lately in thinking very ugly, though an attempt has been recently made to exalt it above the Parthenon, and all that was great and beautiful in Greece, Egypt, or Gothic Europe." In this faith I was born, and in this faith I think I shall die: for it appears to me that the edifice in question owes much of its celebrity to its picturesqueness both of situation and association; and, without these adjuncts, it could not have been worthy of any extended notice. As Fergusson however truly states, the Gothic architecture of Venice is quite distinct both in origin and character from any other found in Northern Italy: it is not derived from the old Lombardian Gothic, but from the richer and more graceful Byzantine. As I have just said, I am free to admit that in its sculptured decorations there is to be found great variety and beauty, as is shown by the casts and the large drawings of Mr. Ruskin. I am also ready to acknowledge that there are some pretty specimens of Domestic Gothic to be found in Venice; and of these the Ca d'Oro is perhaps the most agreeable. Both in this building, however, and in the Ducal Palace, there are the grossest violations of constructive propriety and truth. In the Doge's Palace, besides other irregularities in the façades, the great centre opening is in the middle of three of the upper stories of pillars and arches; and it therefore rests irregularly on the two great openings below which carry four of these smaller openings;—and at the Ca d'Oro there are three irregular openings on the ground floor in the centre, and six immediately above; the bearings are therefore necessarily all false. Mr. Ruskin, however, stoutly defends such peculiarities: any architect would, in my judgment, avoid them if possible.

To return however to the books of our accomplished friend, Mr. Ruskin; his first architectural book, 'The Seven Lamps of Architecture,' is in many respects worthy of great praise. Whatever credit we may be disposed to give to the other six lamps, it cannot be denied that the Lamp of Truth has been most effectually lighted, and has had a considerable influence on modern architecture, and that both in material and essential form of construction; but Mr. Ruskin must not go to Venice to light the lamp of truth at the shrines of Venetian Gothic.

The next important publication of Mr. Ruskin was named 'The Stones of Venice,' the first part of which appeared in 1851, and was devoted to The Foundations. This work, as it regards the second and third volumes, which refer to the Sea Stories and the Fall of Venice, in some respects cannot be too highly esteemed. That part which is entitled The Foundations, leads us only to regret that so much ingenuity and learning, and even wit, should have been thrown away in commendation of a style of architecture which it appears to me impossible to admire for anything but an accidental picturesqueness.

As a specimen of the truthfulness of Mr. Ruskin when he is not misled by that which I cannot but call his architectural fanaticism, take the accurate and excellent description of an Italian building from the second chapter of the third volume of his 'Stones of Venice,' page 32. After this extract, I think the present meeting will wonder with me, that the principal objections which he can find are because the centre opening is of an arched form under a square; and that he does not approve of the capitals of three-quarter columns being "glued to the wall;" but he objects most to "the corrupt moral nature" of this style of building, to be found in its two elements, namely, "Pride and Infidelity!" Poor Palladio and Scamozzi, how much you are to be pitied!

One of the most recent technical books of Mr. Ruskin with which I am acquainted is an account of the lectures which he delivered at Edinburgh in 1854, on architecture and painting. This little volume I presume to represent the most matured opinions of this important writer; the lectures on architecture themselves appear to me to be very unimportant, and often nonsensical, as may be seen in the remarks on the pointed form of the leaves of the ash-tree, which seems to be adduced as a reason why the pointed arch should be preferred. The really important part of this book is contained in the Addenda, and it results in the following six propositions:—"1. That Gothic or Romanesque construction is nobler than Greek construction. 2. That ornamentation is the principal part of architecture. 3. That ornamentation should be visible. 4. That ornamentation should be natural. 5. That ornamentation should be thoughtful. 6. And that, therefore, Gothic ornamentation is nobler than Greek ornamentation; and Gothic architecture the only architecture which should now be built." To the proposition as to Gothic architecture being the only architecture that ought now to be practised I shall say a few words hereafter.

Passing on however from Mr. Ruskin, let me call your attention to a book of a very different character, written by a learned architect, Mr. James Fergusson, entitled 'An Historical Inquiry into the True Principles of Beauty and Art,' published in 1849. Of this work only the first volume is published: but the design appears intended to comprise not only an analysis and history of the fine arts, and of architecture in particular, but an attempt at a systematic application of all the sciences, with especial reference to their connection with the arts. In this book, and in the introduction to the 'Hand-book of Architecture' by the same learned person, are many aspirations after some species of national architecture which is not yet in existence. Mr. Fergusson tells us that no one ever has, and no one ever can, invent a new style of architecture; but that all that we see has grown, one form out of another. This is true; but then, with so much learning and with so much talent, why does not Mr. Fergusson show us himself what he means? A similar remark occurs to me with reference to Mr. Scott's charming but unsatisfactory work—unsatisfactory, because half a dozen sketches would have better shown us what he proposes and wishes, than volumes of the most elaborate description and criticism.

It is impossible for me, and time will not permit me, to refer to the important works of Hope, Petit, Whewell, Willis, and others. I must also pass over another more recent publication, 'The History of Architecture,' by Mr. E. A. Freeman, who I believe is not a professional architect. It appeared in 1849, and I can only agree with the remark of the 'Quarterly' reviewer in relation to it, that "it is too speculative and crotchety, and is entirely deficient in illustration." The very latest criticism is the article I have just referred to in the last 'Quarterly,' on Mr. Fergusson's works; it is ably written, but the remark on Mr. Coningham is as unjust as it is untrue; and I trust that no architect is called upon to agree with the reviewer "that, for some years past opportunities for raising fine monuments such as few nations have enjoyed, have been utterly lost."

With regard to the exact state of architecture in England at the present time, it is impossible, as I have before stated, for me to attempt to criticise particular works. As a whole, it is a matter of exceeding satisfaction to every honest archæologist and architect to see the anxiety which seems to possess all classes of society for preserving and restoring ancient architectural monuments. Again, it is a matter of further congratulation to perceive the wonderful skill, labour, and patience, with which these restorations have been conducted. The characteristics of the archi-

Digitized by Google

tecture of each period are carefully studied, and thoughtfully reproduced; and with regard to Gothic architecture, it is impossible to deny that it is now thoroughly understood. I certainly could wish as an architect that our artists were endowed with more imagination and invention: as the Germans have it, they are more "perceptive than productive." We neither develope what we borrow, nor are we always able to approach the higher productions of the ancient Gothic architects.

I could wish also that for the most part imitation had been not so much the order of the day. The only questions which appear to be asked are—"Is such a work warranted by precedent?"—"Is the ensemble chronologically correct?" In the accuracy of the antiquary or the reproduced discovery of the modern traveller, public taste has been satisfied, instead of looking to the vital principles of architectural progress, which are developed from a consideration of the wants we have to meet; the appliances and materials most accessible for meeting them; and the dictates of construction, fitness, and the appreciation of the beauty, considered independently of association, education, and antiquarianism.

To these remarks as an architect, I must add one or two considerations as a citizen and a member of the Church of England. It appears to me that in the zeal for reproducing mere copies of ancient edifices, the more important demands of our intellectual worship have been neglected; and it is unfortunately too often the case that when one admires a beautiful Gothic church, one is met with the remark by the congregation, particularly the poorer members of it, "It may be all very fine, sir, but we can neither see, nor hear, nor read in it."

Before I conclude this address, it will be necessary for me to say a word more on this subject, but when men are perishing "for lack of knowledge," it appears to me that architectural and archæological considerations might give place, and that, in the words of the 'Quarterly' reviewer of the present month with reference to the church of St. Sophia in Constantinople, "In the magnificent Christian temple built by Justinian, we find the largest obtainable space devoted to the celebration of ceremonies in which one vast congregation is expected to unite. Mr. Fergusson remarks that no domical building of modern times can at all approach St. Sophia's either for appropriateness or beauty; and that if we regard it with a view to the purposes of Protestant worship, it affords an infinitely better model for imitation than anything our own Mediæval architects ever produced." The reviewer adds, "This is an opinion in which we fully concur."

In the early part of this address I have adverted to the subject of *Competitions*, and to the report of the committee of the Institute laid before the special and general meeting on the 24th January 1839. This report appears to me, having referred to it, nearly to exhaust the subject, but the principles on which competitions ought to be conducted are so obvious, as to be easily limited within three or four simple propositions.

First. The instructions should be clear, intelligible, and specific; containing directions so that the drawings should be as much as possible calculated to afford a fair comparative view of the intentions of the architect.

Secondly. The recompense, whether in money or employment, should be distinctly and specifically stated.

Thirdly. There should be the greatest possible opportunity of a public examination of the designs.

Fourthly. That the decision should not only be fair, but made by the judgment of those competent to decide.

These simple principles however, as to the second and fourth, require a little explanation. With regard to the second, it is manifestly unjust to take a premiated design, and place it in the hands of another man to execute. At the same time it is scarcely possible to find a premiated design for any building, however humble, that can be executed without modifications; and a third difficulty naturally arises from meeting the inequality of talent and character. For I need not tell the present meeting that it is one thing to make drawings for a scholastic competition, but that a very different degree of attainment is required, and often different modes of thought and study, for the carrying a design into effect. In point of fact, then, competence and character must be introduced into the question.

With regard to the fourth condition, it appears to me that in all cases any public body ought not to venture to determine upon designs in competition, without the advice and assistance of an experienced architect. Apart from the question of construction, even the commonest principles of architectural knowledge are not appreciated without a severe technical education. I have endeavoured throughout my own professional life to make my meaning apprehended by non-professional judges by this illustration, which I believe to be a true one,—That the modes of thought and consequently of detail, as well as the generalities of style, bear a strict analogy to the peculiarities of language. In point of fact, that Greek architecture, Roman architecture, Italian architecture, Lombardic, Norman, Gothic architecture, are as distinct and as distinguishable as are the languages of those several people; and that if the scholar cannot endure false grammar in the one case, or a mixture of idioms, neither can the architect in the other. But at the same time I am sure the present meeting will bear with me when I say, that we have all seen designs sent for public competition in which were to be found not only faults of idiom or grammar betraying the grossest ignorance, but very often the languages themselves were all confounded together.

This slight reference to public competitions brings me naturally to one of the great questions of the day,—the Competition for the Government Offices. In this case all the requisites which I have enumerated were complied with; the instructions were intelligible and clear; the reward was distinctly announced; the drawings were fairly comparative, and there could be no question of the honour and competence of the judges. Unhappily, however, there was one miscarriage, which has led to most of the subsequent difficulties. Inasmuch as only one building could be erected out of the great mass of propositions open for competition, no doubt the successful architect for that building must have been chosen to carry it out; but after the decision was made public, it became known that in this particular instance, the first premium had been awarded by the professional judges to the architects who were placed sixth only in the order of merit; and that, in point of fact, the architects who received the second premium were entitled to the first. This introduced great difficulty into the discussion. It was agreed on all hands that it was impossible to erect the first design. This led to an inquiry as to the original instructions with respect to the actual site of the offices which had been determined to be built. Grave doubts arose on that subject, the whole proceedings fell into abeyance, and certainly for a time were entirely abandoned. If they had merely remained in this situation the competitors would have had no right to complain, any more than a builder who in competition gives in the lowest tender for a building has a right to complain if the estimate should be so large as to prevent the work from being executed at all. In the one case the architect gets both his premium and his reputation; and in the other the successful competitor amongst the builders is entitled both by law and equity to the expense of making his estimate.

But the ministry of the country having been changed, the question assumed another shape; and, in the midst of the difficulties, the government resolved on referring all the questions to the examination of a parliamentary committee. Of the composition of this committee no one could complain: it was fairly chosen as regards politics or opinions; it was presided over by a man of learning; but it was perfectly well known that there was in it a great preponderance of feeling in favour of Gothic architecture. The report of the committee did not very much improve the business. But excepting the statement, that apart from the evidence that Gothic architecture was not essentially dearer than Classical architecture, and might as well be adapted to the common purposes of business, the government was not legally bound to employ the successful competitor. The committee therefore generally left the question to be dealt with as the government thought fit. To me, however, it appears indisputable that the premiated plan No. 2, ought to have been adopted; because it was agreed on all hands that the arrangement suggested met the requirements of the case far better than those of any other plan; and that the elevations and external decoration were moderate, agreeable, and consistent.

If the feeling of the country were so decidedly in favour of Gothic architecture, that Gothic forms and Gothic decoration were to be considered essential, there was nothing in plan No. 2 to prevent the adoption of that style; and it was perfectly well known that the accomplished architects who had designed and arranged the external elevation in the Italian style could just as easily, if required, have adapted the architecture of any other nation or period.

I think however, to say the least, that the employment of the author of the plan No. 3 was unjust to the architect who

Digitized by Google

had gained the second premium, and also unjust to our profession.

It is not my purpose to revive at this meeting or to promote a discussion or a re-discussion of all that has followed, whether in the House of Commons or in society. I am prepared to maintain the opinions I have always expressed, that the architecture of the approved design is neither Gothic nor national, in the sense that these terms are understood by the lovers of Gothic architecture; that it is very considerably more costly than the same amount of building in the Italian style of architecture; that it is neither so well adapted nor fitted for the purposes to which it would be applied as Italian architecture; and that the building if erected as proposed, whether Gothic or Italian, will involve the destruction of the State Paper Office on the west, and of all the important offices on the south now forming the west end of Downing-street. This will not be at all the fault of either architect; but if the edifice be erected as it is at present arranged, it can only prove to be a blot and an incongruity.

The remaining topic to which I have to call your attention is *the Future of Architecture*, but what that future is to be it is impossible for me to predicate; since our young architects seem educated only in the learning and knowledge of Mediæval architecture. Construction in iron has reached a point of excellence, owing to the suggestions of Stephenson and Fairbairn, which fifteen years ago was not even dreamed of; but still its forms are concealed in architecture by a degree of untruth which must be very unsatisfactory to Mr. Ruskin. The great glasshouse of the Crystal Palace can find no imitators, excepting for the limited appliances of horticulturists; and for my own part I see no prospect, in this utilitarian age, of anything but a copy of what has been done before, instead of the realisation of the hopes of Mr. Fergusson, or the dreams of Mr. Ruskin.

In the meantime, let me exhort the young and those who are their teachers in art, to attain to and to communicate a solid and substantial acquaintance, first with the principles of construction, and next accurately with the grammar of the Greek, Italian, and Gothic systems. All these three latter are now easily obtained, and I hope that some day some architect, more adventurous and more successful than the rest of us, may strike out something new; but, without the preliminary knowledge which I have pointed out, the novelty will only be, as it very often is, a cover for ignorance.

Looking at the solemn scene which passed only the other day, when the mortal remains of one of our greatest scientific men were deposited within the walls of one of our very finest ancient buildings, I will ask every young man who hears me, to follow the path marked out by Robert Stephenson, if he would attain to the eminence both scientific and social which he so well deserved. In early youth his education was a careful and a sound one: he was an excellent mathematician, without which any architectural education is but nothing worth. In after-life he was patient, thoughtful, honourable, honest, and in social association one of the most generous and kindest of friends; and his private and public benevolence were as large as his means of gratifying them.

And now, in conclusion, for a few practical words. I have endeavoured to sketch out (very imperfectly, it is true) the progress of the mind of our generation with reference to architecture and archæology, and I have told you something of what the last twenty-five years has produced in architecture itself. I have endeavoured to show you by the inconsistencies of those critics who would seek to force one style and one style only upon us, that by their own admissions they do great wrong to the claims of the great minds of other nations, of other periods, of other styles of art, and of the greatest works in the world, the produce of our own countrymen. Why should we—in praising the works of William of Wykeham or of the architects of the Gothic period, and urging the adoption of the Gothic style—forget the infinitely greater claims of Sir Christopher Wren, Inigo Jones, or Sir William Chambers? Why should we go back to the rude architectural forms and arrangements of a comparatively barbarous period? And why not press forward to avail ourselves to the full of the advantages of the increasing knowledge and civilisation of our own? Are only the men who had their floors covered with rushes, their lights in horn lanterns, and who carried their glazed sashes about with them on their pack-horses, to be studied, copied, venerated? Everything may be right which is put in its right place: let Gothic architecture be studied and used where it is convenient, becoming, characteristic, and appropriate; but let it not obtrude itself into our club-houses, our museums, our courts of justice, nor, if I may be permitted to say so, into our public offices. As to ourselves, in these our new, convenient, almost splendid apartments, let us endeavour to be a united body, to claim for our own art the place it deserves, and to deserve that place by bringing learning, travelling experience, skill in the various and difficult branches of our scientific pursuits, and gentlemanly demeanour and forbearance, to justify our claims.

Be not misled either by the influence of great names. Think for yourselves; disregard the dictates of fashion; "be sober, be diligent:" recollect the aphorism of one of our greatest artists, "Excellence was never granted to man but as the reward of labour." Before I finish, I would appeal also to the world in favour of the younger members of my profession especially. May I say to the patrons of architecture,—Seek out the well-informed and educated architect, and do not believe in that fallacy, by far too common in England, that because a man is a gentleman and a scholar, he cannot be practical. The greatest practical architect of our own or of any other country, Sir Christopher Wren, and the greatest practical engineer of our own time, Robert Stephenson, were eminently, both the one and the other, scholars and gentlemen! Men merely connected with the incidental trades engaged in building are not architects, though they often call themselves by that high-sounding name, and assume functions which they have no right to claim. The world in this matter does us great wrong, and then blames us for want of success, when they have themselves rejected the instruments they ought to have chosen.

As a last parting reflection, let us not forget in our scientific pursuits the shortness and uncertainty of life. "Let us work," as Christians and as men, "while it is called to-day, for the night cometh when no man can work." We may also recollect with some advantage the aphorism of the old Greek physician: part of it is very trite, but the whole of it is very true:—

> "Life is short, Art long, Opportunity fleeting,
> Experience fallacious, and Judgment difficult."

ON THE ESTABLISHMENT AT CAMBRIDGE OF A SCHOOL OF PRACTICAL SCIENCE.*

By the Rev. Henry Latham, M.A.

The idea of starting a school of civil engineering at Cambridge was much discussed in the years 1845 and 1846; but during the depression of the railway interest the matter dropt. In the years 1853 and 1854 a select committee was appointed by the Cambridge Senate, to consider how the studies of the University could be best extended and improved; and a correspondence was opened with the chief schools of engineering. The uniformly discouraging accounts of failures which were then received, and the strong opposition which, it was stated, was manifested to all such schools by many of the influential houses in the profession who received articled pupils, were such, that the committee could not recommend the establishment of such a school in Cambridge.

Until the new constitution, lately granted by the Cambridge University Commissioners, placed means at the disposal of the University, no scheme could have been adopted which was not self-supporting. It is very different abroad. There all enterprises, and polytechnic colleges amongst the rest, are carried on by the government.—A handsome school is erected, named after the ruling prince, and so many thousand florins are assigned to the payment of the professors, whose appointments are so much more government patronage. Under its new constitution, however, the University of Cambridge has more funds placed at its disposal, and may before long proceed to strengthen the professorial staff: it is well, therefore, to get to know clearly what new courses of study may be established with prospects of success. It is with this view that attention is now drawn to the establishment of a University School of Practical Science

In the plan proposed for this school care will be taken, in the first place, to keep it from falling into the hands of the teachers of theoretical science, who would be likely to give it an unpractical tone. Thus it will be distinct from the ordinary mathematical tripos, and under the control of a distinct board of studies in which the practical professors would exert the greatest influence.

Teaching a science is one thing, and training a man for a profession is another. The University will only undertake to

* Abstract of a Paper read at Bradford, at the National Association for promoting Social Science.

Digitized by Google

attempt the former: it would be very erroneous to jumble the two together. Every care will be taken that the science shall not be taught in such a way as to unfit a student for his professional training; and it will be strange if the instruction of the Cambridge professors Willis and Stokes, who at present are at the heads of departments in the Government School of Mines, and whose instruction is eagerly sought in London, fail to attract students to Cambridge; where great facilities for general education, and a University title, will be offered.

The collegiate course is not meant to be a rival to one upon works; on the contrary, it is supposed that the young men who will offer themselves as students will be articled pupils to a civil or mechanical engineer, or else in some establishment of practical art, either during their course or immediately after it. Engineering has a *business* side as well as a scientific one: still, it would be wise of masters of establishments, and probably directly remunerative, to allow their pupils four terms, *i.e.*, four periods of about eight weeks each—at intervals if need be, to enable them to acquire that varied scientific knowledge and training in drawing, &c. which can hardly be acquired in workshops, still less in a single one. Every day a higher kind of scientific knowledge is being brought to bear on the business of life, while a sound conception and firm grasp even of the more elementary principles is not to be obtained without really good teaching; and the local (middle class) examinations have proved that this is not to be had everywhere.

In the *Times* of 14th March last it was announced that a number of appointments under the Engineers' Establishment and Public Works Department of India, would be thrown open for public competition. Only fifteen candidates presented themselves. This is symptomatic of the want of centres of education at which candidates can be prepared: and so is the further fact, that only one of the fifteen reached the prescribed *minimum* of marks.

In Germany there was a rage a few years ago for being practical. The Germans then laid too much stress on manual labour. German gentlemen have insisted upon their sons working as navvies, blacksmiths, and joiners. A gentleman in Germany describes how he was saluted with a Latin quotation by one of a gang of navvies, who turned out to be an old schoolfellow serving an apprenticeship as a civil engineer. A student thus left to himself, in order that he should not learn anything which he cannot himself find out, no doubt prizes very highly what little he acquires with great difficulty, and with so considerable a measure of social hardship; but a quicker and more excellent method of instruction than this can certainly be found. The Germans are beginning to put less stress on this element of education, and more upon scientific instruction. And the rapidly growing value of the improved German education—especially in scientific mechanism—may be inferred from the fact, that the house of Borsig in Berlin carried off the prize for locomotives at the Paris Exposition, from English competitors; and that in many large engineering works in Warwickshire, Lancashire, and Yorkshire, employing 1000 hands, the active originating practical manager is a German.

Hence it is important for the national honour that scientific lectures should be promoted in England, and recognised by professional men of standing; and that too in spite of the large and repectable class of safe personages, who think that they fulfil their duty to society by sitting still and crying down every attempt at this.

[We can only afford space for a briet sketch of the scheme here proposed for the Cambridge Practical School.] It is proposed to admit no students under 16 years of age; and these will be admitted as members of a college, either before or after entering on their articles. They would thus benefit by the discipline and advantages of a University career; and might reside during any time when business was slack, or residence otherwise convenient. During each term of residence (of about eight weeks) they would be able to attend lectures upon, (1) Mechanism applied to the Arts; (2) Civil Engineering; (3) Geology; (4) Mineralogy; (5) Chemistry; (6) Metallurgy; (7) Field Surveying. The students would be examined on admission in the usual branches of an English education, unless they had already obtained a certificate at a local examination; further, they would pass at some period of their course the mathematical portions of the open University examinations for the B.A. degree, including Euclid, elements of algebra, and elementary mechanics and hydrostatics. Finally, each student would attend at least four of the above lectures, in which civil engineering would count as two. He would then be admitted to the title of Associate of Practical Science, or A.P.S. Thus would be avoided the error, prevalent in German Universities, of marking out the University course too rigidly; and also that of leaving the students entirely without college discipline.

Thus the University offers a scheme of scientific education, as it is its duty to society to do: but it is only the profession who can tell what ought to be the education in such a subject as engineering, which would best meet its constantly shifting requirements. It would be rendering a great service if any public body connected with this profession would state authoritatively what they hold to be the main requisites of any course of preparation for young men desiring to enter it.

EXPERIMENTS ON CAST-IRON.

A series of valuable experiments has recently been carried on under the superintendence of Col. F. Eardley-Wilmot, superintendent of the Royal Gun Factories at Woolwich, upon various British irons, with a view to determine the most suitable varieties for the manufacture of cast-iron ordnance. The results of these experiments are printed in a tabular form in a parliamentary report lately issued. The tables occupy nearly the whole of a thick folio book, and show the strength of various specimens of iron supplied by the principal ironfounders of the kingdom, when subjected to tensile, transverse, torsion, and crushing tests.

"The general results of a considerable number of such experiments is shown in the following table:—

	Specific gravity of 850 specimens.	Tensile of 860 specimens.	Transverse of 564 specimens.	Torsion of 276 specimens.	Crushing of 273 specimens.
Maximum	7 340	34,279	11,321	9,773	140,056
Minimum	6 822	9,417	2,586	3,705	44,563
	Of fifty-one samples.	Of fifty-one samples.	Of fifty-three samples.	Of fifty-one samples.	Of fifty-one samples.
General mean ...	7·140	23,257	7,102	6,056	91,061

From the prefatory remarks to the tables we quote the following passages, which indicate some remarkable peculiarities in the condition of the specimens of iron, and the effects which a slight change of circumstances in casting produced on the strength of the metal.

"The results already obtained by various experiments on the subject of remelting cast-iron are well known, and have been repeated at various times in this department; when, however, the experiment is made with large masses of iron of several tons, the effect produced is not so marked. It would appear that without any considerable diminution of the impurities in the metal, as silicon, sulphur, and phosphorus, a considerable increase of tenacity and specific gravity can be obtained. The graphite is partially expelled, and some of it is converted into combined carbon, and the contraction and crystallisation is more energetic and complete. This combined carbon can, it is thought by some, on again remelting the mass, and very slowly cooling it, be reconverted to graphite, rendering the iron soft and fusible. This is undoubtedly the case with the product of the refinery process known as 'metal,' the use of which on this principle formed the subject of a patent by Dr. Price in 1856.

There is a point not probably accurately determined at which the maximum hardness corresponding to the maximum tenacity may be found. In an iron cannon there is however required an elasticity in addition to other qualities, when these qualities are not in excess to such an extraordinary degree as to render the mass so strong and rigid as to obviate any danger of disruption. It has been found in the various experiments made at Woolwich, that in most cases where the specific gravity is 7·3 or upwards, the metal is unsuited for gun purposes, on account of its hardness and want of elasticity; while the same iron treated in the furnace for a shorter time, and being when cast of a lower specific gravity and less tenacity, would have resisted more satisfactorily the explosion of the powder.

The most decided features to be observed in the results are the universal and very marked superiority of the bars in the cases where they have been cast horizontally over those cast vertically; and the superiority, but in a less marked degree, of the bars cooled quickly over those cooled gradually or slowly. It is to this rapid cooling and condensation that the superior strength of a 2-inch bar cast from a portion of the metal of which a gun is made is due.

This is almost universally found to be the case in the experiments

Digitized by Google

hitherto made with a portion of metal taken from the dead-head, close to the muzzle of the gun, as compared with the bar cast at the time of making the gun.

The contrast as regards appearance is equally marked. In the bar a close grey rigid appearance; in the dead-head a large grain with graphitic masses joined or cemented together with a whiter and harder material.

The demand for the manufacture of iron ordnance, and the necessity for the supply of a certain number to meet what is expected in this country of a new government establishment, has prevented such various experiments being made as are desirable. At a new government foundry on the continent, established about the same time, two years were allowed for experiments before a 'supply' was demanded. It would appear that a great deal is still to be done on this subject, and that we are only now at the commencement of vast improvements in the manufacture of cast-iron and cast-steel."

NOTES ON DYNAMICS.

By ARTHUR COHEN, B.A., Magd. Coll. Camb.

THE following paper is a continuation of a preceding one by the writer in the present volume of this Journal (page 217), and its object is to prove by a new and simple method, and without complicated analysis, the principal formulæ of the motion of a particle.

§ 1. There are many reasons why the diagonal AD of the parallelogram constructed on the straight lines AB and AC should be considered in the light of the sum of those two straight lines. Such reasons are to be found developed in De Morgan's 'Double Algebra,' Warren on 'Imaginary Quantities,' Peacock's 'Algebra,' and moreover in an admirable paper written by Prof. De Morgan in the 'Transactions of the Cambridge Philosophical Society,' vol. x. part ii. There are also some interesting observations of John Stuart Mill "on the Composition of Causes," which bear closely upon this subject, and are contained in the sixth chapter of his work on 'Logic.'

§ 2. I propose then in this essay to call AD (AD being the diagonal of the parallelogram constructed on AB and AC) *the complete sum* of AB and AC, and AB and AC the components of AD; and denoting AD, AB, AC, by R, P, Q respectively, I intend to express this relation by the formula

$$R=(P)+(Q).$$

Where however there is no chance of any mistake, I shall often omit the brackets in the last formula, and also speak of R as being the sum of P and Q.

If a line Q has q for its length, and is parallel to a given line OP, I shall sometimes denote the line Q by (q parallel to OP).

§ 3. Lines will be here considered equal to one another if they have the same length and are parallel.

I shall denote by (−Q) a line equal and opposite to Q, and define (P)−(Q), which I call *the complete difference of* P *and* Q, to be the same as (P)+(−Q).

§ 4. Suppose then a line Q to vary with the time t both in length and direction: the complete difference of two successive values of Q after an increment Δt of the time, will be called *the complete increment* of Q during that interval, and will be denoted by $\Delta(Q)$.

If we divide the length of $\Delta(Q)$ by Δt, and take the limit of that ratio, then that line which has such limit for its length, and for its direction the direction to which $\Delta(Q)$ indefinitely approaches, will be called *the complete differential coefficient of* Q, and will be denoted by $D_t(Q)$.

§ 5. The following propositions may be easily shown to flow at once from the above definitions:

I. The complete difference of any two straight lines OB and OA, viz. (OB)−(OA), is equal to AB.

II. The projection of the complete sum or difference of P and Q on any line is equal to the sum or difference of their respective projections on that line.

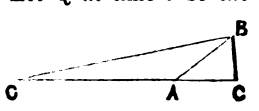
III. If R=(P)−(Q), then R−(P)+(Q)=0; in short, the ordinary rule of signs in algebra holds good.

IV. If $R=(P)\pm(Q)$, then $D_t(R)=D_t(P)\pm D_t(Q)$.

§ 6. I shall moreover extend the same expressions and notation to all magnitudes which can be adequately represented by a straight line of definite length and direction, and which are compounded according to the law of the parallelogram of forces, as for instance, pressures, velocities, accelerating and moving forces, momenta, couples, and angular velocities of rotation. The law of composition of these magnitudes can be proved independently for each of them, but Prof. De Morgan, in the paper cited above, has shown that the law of composition embodied in the proposition of the parallelogram of forces depends merely on a few simple postulates, which can be easily proved to be true in respect of all the different magnitudes I have just mentioned.

§ 7. Suppose now a straight line Q to vary in position and magnitude, it is proposed to investigate its complete differential coefficient.

Let Q at time t be the straight line OA, and let it become $Q+\Delta(Q)$, or OB at time $t+\Delta t$, the angle OAB being $\Delta(Q)$, and OA and AB having q and $q+\Delta q$ for their respective lengths. Produce OA to C, making $OC=OB=q+\Delta q$



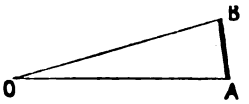
$\therefore AC=\Delta q$. Now $\Delta(Q)=(OB)-(OA)=AB=(AC)+(CB)$. Therefore

$$D_t(Q)=\left(\text{limit of }\frac{AC}{\Delta t}\right)+\left(\text{limit of }\frac{CB}{\Delta t}\right)$$

But the limit of $\frac{AC}{\Delta t}$ is evidently a line whose length is limit of $\frac{AC}{\Delta t}=\frac{dq}{dt}$, and whose direction is that of Q or OA. And the limit of $\frac{CB}{\Delta t}$ is, since COB is an isosceles triangle, a line whose length is the limit of $q\frac{\Delta\theta}{\Delta t}=q\frac{d\theta}{dt}$, and whose direction is perpendicular to that of Q, and in the plane in which Q begins to turn.

Thus we see that the complete differential coefficient of Q is compounded of two lines, one in the direction of Q, the other perpendicular to it; the former having $\frac{dq}{dt}$, the latter $q\omega$ for its length, ω being the angular velocity with which the direction of Q is varying; and since it is clear that the former line would be the differential coefficient of Q if the length q alone varied, and the latter line would be its differential coefficient if its direction alone varied, we may say that the differential coefficient of a line is the complete sum of its two partial differential coefficients, supposing the length and the direction separately to vary.

§ 8. Suppose a particle to be moving in a curve from A to B, and let O be a fixed point. Then (OB)−(OA)=AB. Now the velocity of a particle is by its very definition represented in magnitude and direction by the limit of $\frac{AB}{\Delta t}$; therefore the velocity is identical with the complete differential coefficient of the radius vector.



§ 9. Again, let OA and OB in the last figure represent the successive velocities of a moving particle; then if with velocity OA we compound the velocity AB, we obtain the velocity OB; therefore evidently the accelerating force, or to speak more correctly the acceleration, is represented by the limit of $\frac{AB}{\Delta t}$, and is therefore by the preceding the differential coefficient of OA. I therefore define the acceleration of a particle to be *the complete differential coefficient of the velocity.*

The above shows how the dynamics of a particle may be considered as treating of the complete differential coefficients of lines, concerning which differential coefficients I shall now proceed to prove the most important propositions.

§ 10. I have already proved that if Q be a line whose length is q and whose direction is varying, with an angular velocity ω at time t, then

$$D_t(Q)=\left(\frac{dq}{dt}\text{ in direction of Q}\right)+(q\omega\text{ in direction perpendicular to that of Q and in the plane in which Q is moving})\ \ldots\ (I.$$

Let now Q be the velocity of a particle, q the magnitude of the velocity v; ω the rate at which the direction of the velocity,

Digitized by Google

i.e. of the tangent, is varying: then it is clear that if $d\psi$ be the angle made by two consecutive tangents to the curve, $\omega = \frac{d\psi}{dt} = \frac{d\psi}{ds} \cdot \frac{ds}{dt} = \frac{v}{\rho}$, ρ being the absolute radius of curvature. From (I.) we find therefore, for the complete differential coefficient of the velocity or the acceleration of a particle,

$$\left(\frac{dv}{dt} \text{ in direction of the tangent}\right)$$

together with $\frac{v^2}{\rho}$ in direction of the absolute radius of curvature.

§ 11. Again, let Q be a straight line of length q, and let Q_x, Q_y, Q_z, be the components of Q parallel to three fixed axes, Ox Oy Oz, Q_x Q_y Q_z having for their lengths respectively q_x, q_y, q_z.

We have then $Q = (Q_x) + (Q_y) + (Q_z)$

$$\therefore D_t(Q) = D_t(Q_x) + D_t(Q_y) + D_t(Q_z).$$

Now clearly $D_t(Q_x)$ = a line whose direction is that of Ox, and whose length is $\frac{dq_x}{dt}$. So that the component of $D_t(Q)$ parallel to Ox is a line whose length is $\frac{dq_x}{dt}$.

Apply this firstly to velocities. Since the component of the radius vector parallel to Ox is x, it follows that the component of the velocity parallel to Ox is $\frac{dx}{dt}$.

Secondly, apply it to accelerations. Let the component of the velocity parallel to Ox be v_x which we have found to equal $\frac{dx}{dt}$. Since the acceleration is the complete differential coefficient of the velocity, it follows that the component of the acceleration parallel to Ox is $\frac{d(v_x)}{dt} = \frac{d^2x}{dt^2}$.

---

§ 12. Let us now take the case of Q being resolved along variable axes of co-ordinates.

Suppose Q to move in one plane, and the axes of x and y to be in that plane, and to revolve with an angular ω at time t. We have as before,

$$Q = (Q_x) + (Q_y)$$
$$\therefore D_t(Q) = D_t(Q_x) + D_t(Q_y) \quad \ldots \quad \ldots \quad \text{(I.)}$$

But we have proved that

$$\left.\begin{aligned} D_t(Q_x) &= \left(\frac{dq_x}{dt} \text{ parallel to } Ox\right) + (\omega q_x \text{ perpendicular to } Ox) \\ D_t(Q_y) &= \left(\frac{dq_y}{dt} \text{ parallel to } Oy\right) + (\omega q_y \text{ perpendicular to } Oy) \end{aligned}\right\} \text{(II.)}$$

Since the said lines ωq_x, ωq_y are respectively perpendicular to Ox and Oy, and are in their lengths proportional to q_x, q_y, they are together equivalent to ωq in direction perpendicular to that of Q, because namely the lines (q_x parallel to Ox) and (q_y parallel to Oy) are together by hypothesis equivalent to q in direction of Q. Therefore looking at equations (I.) and (II.), we see that $D_t(Q)$ is equivalent to

$$\left(\frac{dq_x}{dt} \text{ parallel to } Ox\right) \text{ and } \left(\frac{dq_y}{dt} \text{ parallel to } Oy\right) \text{ together with}$$

(ωq in direction perpendicular to that of Q).

§ 13. The above result is true for oblique as well as rectangular axes, but if we suppose the axes rectangular, then ($q_y \omega$ perpendicular to Oy) is ($-q_y \omega$ parallel to Ox), and the formula (II.) becomes

$$D_t(Q) = \left(\frac{dq_x}{dt} - q_y \omega \text{ in direction of } Ox\right) + \left(\frac{dq_y}{dt} + q_x \omega \text{ in direction of } Oy\right) \ldots \quad \ldots \text{(III.)}$$

In fact ($-q_y \omega$ parallel to Ox) and ($q_x \omega$ parallel to Oy) are the components of (ωq perpendicular to the direction of Q).

§ 14. These results may be also proved in the following manner, which will be found useful in the sequel. Let, after an interval of time Δt, the magnitudes Q, q, Q_x, Q_y, q_x, q_y, become respectively Q', q', Q'_x, Q'_y, q'_x, q'_y; and let the axes come into the positions Ox', Oy'. Let $q'_x = q_x + \Delta q_x$ $q'_y = q_y + \Delta q_y$

$$\therefore Q = (q_x \text{ parallel to } Ox) + (q_y \text{ parallel to } Oy)$$
$$Q' = Q + \Delta(Q) = (q_x + \Delta q_x \text{ parallel to } Ox') + (q_y + \Delta q_y \text{ parallel to } Oy')$$

Let now (q_x parallel to Ox')+(q_y parallel to Oy') be the line Q''. Then

$$\Delta(Q) = (Q') - (Q) = (Q'') - (Q') + (\Delta q_x \text{ par. to } Ox') + (\Delta q_y \text{ par. to } Oy') \ldots \text{(IV.)}$$

Q'' has evidently for its length q, and since it must have with reference to the axes Ox' Oy' the same position as Q has with reference to the axes Ox Oy, it follows that the direction of Q'' is that in which Q would come were it to move with the axes Ox Oy as if rigidly connected with them; that is to say therefore, as if it were to revolve with an angular velocity ω about O.

Therefore (Q'')—(Q) is ultimately a line whose direction is that in which the extremity of Q would begin to move if Q were rigidly connected with Ox and Oy, and whose length is $q\omega$.

Now dividing equation (IV.) by Δt, and taking the limit, it follows that

$$D_t(Q) = \left(\frac{dq_x}{dt} \text{ parallel to } Ox\right) + \left(\frac{dq_y}{dt} \text{ parallel to } Oy\right) + (R)$$

where R is a line whose length is ωq, and whose direction is perpendicular to that of Q. It may be observed that R is what the complete differential coefficient of Q would be if the lengths of the components of Q did not vary, and their directions only changed.

§ 15. Let us apply these results first to the velocity of a particle, of which I suppose x and y to be the co-ordinates. Let v_x and v_y be the components of the velocity v; then since the velocity is the complete differential coefficient of the radius vector, of which x and y are the projections on the axes, it follows from the above at once that the velocity equals

$$\left(\frac{dx}{dt} \text{ parallel to } Ox\right) + \left(\frac{dy}{dt} \text{ parallel to } Oy\right) + (\omega r \text{ perpendicular to the radius vector}),$$

and if the axes be rectangular, then the formula (III.) gives at once

$$v_x = \frac{dx}{dt} - y\omega$$
$$v_y = \frac{dy}{dt} + x\omega$$

§ 16. Let us proceed to apply the above to accelerations. It follows then at once, whether the axes be oblique or rectangular, that the acceleration equals

$$\left(\frac{dv_x}{dt} \text{ parallel to } Ox\right) + \left(\frac{dv_y}{dt} \text{ parallel to } Oy\right) + (\omega v \text{ along the normal})$$

and if the axes be rectangular, then

$$\left.\begin{aligned} \text{The acceleration parallel to } Ox &= \frac{dv_x}{dt} - v_y \omega = \text{say } F_x \\ \text{The acceleration parallel to } Oy &= \frac{dv_y}{dt} + v_x \omega = \text{say } F_y \end{aligned}\right\} \text{(V)}$$

Substituting for v_x and v_y their values, we find

$$F_x = \frac{d^2x}{dt^2} - 2\omega\frac{dy}{dt} - \omega^2 x$$
$$F_y = \frac{d^2y}{dt^2} + 2\omega\frac{dx}{dt} - \omega^2 y$$

Now $\left(2\omega\frac{dy}{dt} \text{ parallel to } Ox\right) + \left(2\omega\frac{dx}{dt} \text{ parallel to } Oy\right)$ equals evidently ωv along the normal. And

$$(-\omega^2 x \text{ parallel to } Ox) + (-\omega^2 y \text{ parallel to } Oy)$$

equals evidently $-\omega^2 r$ along the radius vector.

Therefore the total acceleration equals

$$\left(\frac{d^2x}{dt^2} \text{ parallel to } Ox\right) + \left(\frac{d^2y}{dt^2} \text{ parallel to } Oy\right) + (2\omega v \text{ along the normal}) + (-\omega^2 r \text{ along the radius vector}).$$

This is a result to which we shall subsequently recur.

§ 17. Let us now find the acceleration parallel and perpendicular to the radius vector.

Since then in this case $v_x = \frac{dr}{dt}$, $v_y = r\frac{d\theta}{dt}$ and $\omega = \frac{d\theta}{dt}$, the formula (V.) gives at once for the acceleration parallel to the radius

Digitized by Google

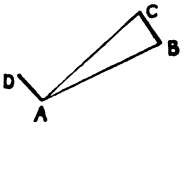
vector $\frac{d^2r}{dt^2} - r \cdot \frac{d\theta^2}{dt^2}$, and for the acceleration perpendicular to the radius vector,

$$\frac{d}{dt}\left(r\frac{d\theta}{dt}\right) + \frac{dr}{dt}\frac{d\theta}{dt} = \frac{1}{r}\frac{d}{dt}\left(r^2\frac{d\theta}{dt}\right)$$

---

§ 18. I will here stop to show how the formula for the acceleration perpendicular to the radius vector may be made to flow from very simple considerations.

Let AB and AC represent two consecutive velocities of a particle moving in one plane. In that plane take any point O as origin of co-ordinates. Draw AD equal and parallel to BC. Then since AC is compounded of AB and AD, it follows from statics that the moment of AD about O equals the difference of the moments of AC and AB, which difference is the increment of the moment of the velocity, or $\Delta(pv)$, p being the perpendicular from O on the tangent AB, and v the velocity AB.



Now $\frac{AB}{\Delta t}$ has for its limit the acceleration of the particle. Therefore the moment of that acceleration equals

$$\frac{d}{dt}(pv) = \frac{d}{dt}\left(r^2\frac{d\theta}{dt}\right)$$

But the moment of the acceleration equals the product of the radius vector and the acceleration perpendicular to it; therefore the latter acceleration equals

$$\frac{1}{r}\frac{d}{dt}\left(r^2\frac{d\theta}{dt}\right)$$

§ 19. The last important case to consider (and this is one very important with reference to the dynamics of a rigid body) is the case of the complete differential coefficient of a straight line being required, when its components parallel to three rectangular axes Ox Oy Oz are given, and the system of those axes itself revolves about O.

Let at time t the system be revolving about a line OA, whose direction cosines with reference to the axes are $l\,m\,n$, and with an angular velocity ω.

Let the components of Q be Q_x, Q_y, Q_z, and let those lines have for their respective lengths q_x, q_y, q_z; then exactly as in paragraph (19), so we might in this case prove that

$$D_t(Q) = \left(\frac{dq_x}{dt} \text{ parallel to } Ox\right) + \left(\frac{dq_y}{dt} \text{ parallel to } Oy\right) + \left(\frac{dq_z}{dt} \text{ parallel to } Oz\right) + \text{a line R,}$$

where R has for its length $q\omega$, and for its direction that direction in which the extremity of Q would begin to move, if Q were to rotate with the co-ordinate axes with an angular velocity ω about OA: its direction is therefore perpendicular to that of Q and to that of OA. Therefore, as is seen at once from Analytical Geometry of three dimensions, R has for its components

$$\omega(q_z m - q_y n) \text{ parallel to } Ox$$
$$\omega(q_x n - q_z l) \text{ parallel to } Oy$$
$$\omega(q_y l - q_x m) \text{ parallel to } Oz$$

If then the rotation of the system of co-ordinate axes be represented by angular velocities ω_x, ω_y, ω_z about Ox, Oy, Oz respectively, then since $\omega_x = l\omega$, $\omega_y = m\omega$, $\omega_z = n\omega$, it follows that the above expressions for the components of R are

$$q_z\omega_y - q_y\omega_z, \text{ \&c.}$$

Therefore the component of $D_t(Q)$ parallel to Ox is

$$\frac{dq_x}{dt} + q_z\omega_y - q_y\omega_z.$$

Now let us apply the above to velocity. The velocity=complete differential coefficient of the radius vector, whose components are x, y, z; therefore it follows at once, that if v_x, v_y, v_z denote the components of the velocity, we have

$$v_x = \frac{dx}{dt} + z\omega_y - y\omega_z, \text{ \&c.}$$

Secondly, apply it to the acceleration of a particle. Let F_x, F_y, F_z be its components, then it follows at once that

$$F_x = \frac{dv_x}{dt} + v_z\omega_y - v_y\omega_z, \text{ \&c.}$$

Thirdly, apply the above to a very important case, namely, to that of a line whose components are $A\omega_x$, $B\omega_y$, $C\omega_z$ respectively, A B C being constants. Then the complete differential coefficient of the line will have for its components

$$A\frac{d\omega_x}{dt} + (C-B)\omega_y\omega_z \text{ parallel to } Ox$$
$$B\frac{d\omega_y}{dt} + (A-C)\omega_z\omega_x \text{ parallel to } Oy$$
$$C\frac{d\omega_z}{dt} + (B-A)\omega_x\omega_y \text{ parallel to } Oz.$$

---

§ 20. Having proved the principal formulæ which occur in the Dynamics of a particle, I wish to indicate their connection with Double Algebra by one example (see De Morgan's Trigonometry). Let Q be a line whose length is r, and which makes with the axis of x an angle θ. Denote Q also by (r, θ). Then according to the principles of double algebra

$$Q = re^{\theta\sqrt{-1}}$$
$$\therefore D_t(Q) = \frac{dr}{dt}e^{\theta\sqrt{-1}} + r\frac{d\theta}{dt}\sqrt{-1}e^{\theta\sqrt{-1}}$$
$$= \left(\frac{dr}{dt}, \theta\right) + \left(r\frac{d\theta}{dt}, \theta + \frac{\pi}{2}\right)$$

Therefore the velocity of a particle has for its components parallel and perpendicular to the radius vector, $\frac{dr}{dt}$ and $r\frac{d\theta}{dt}$ respectively.

If we differentiate again the equation

$$D_t(Q) = \left(\frac{dr}{dt} + r\frac{d\theta}{dt}\sqrt{-1}\right)e^{\theta\sqrt{-1}}$$

we obtain the expression

$$D_t^2(Q) = \left(\frac{d^2r}{dt^2} - r\frac{d\theta^2}{dt^2}\right)e^{\theta\sqrt{-1}} + \left(\frac{d}{dt}\left[r\frac{d\theta}{dt}\right] + \frac{dr}{dt}\frac{d\theta}{dt}\right)\sqrt{-1}e^{\theta\sqrt{-1}}$$

which gives at once the expressions for the accelerations along and perpendicular to the radius vector, for the last formula represents a line $\frac{d^2r}{dt^2} - r\frac{d\theta^2}{dt^2}$ along the radius vector, and the line $\frac{1}{r}\frac{d}{dt}\left(r^2\frac{d\theta}{dt}\right)$ perpendicular to it.

---

§ 21. Before concluding this paper I will show, in order to familiarise the reader with the above processes, by a somewhat general example, how usefully the notion of the differential coefficient of a line can be applied to the solution of problems in the dynamics of a body.

Take the case of a particle moving in a plane tube, which is itself constrained to rotate with a constant angular velocity ω about a point O in the plane. Take O for origin of co-ordinates, and let Ox, Oy be rectangular co-ordinate axes, which revolve with the tube as if rigidly connected with it. Then we shall apply the formula

$$D_t(Q) = \left(\frac{dq_x}{dt} \text{ parallel to } Ox\right) + \left(\frac{dq_y}{dt} \text{ parallel to } Oy\right) + (\omega q \text{ perpendicular on Q}) \ldots \ldots \ldots \text{(I.)}$$

Take for Q the radius vector of the particle; its components are x and y, and clearly the line

$$\left[\frac{dx}{dt} \text{ parallel to } Ox\right] + \left[\frac{dy}{dt} \text{ parallel to } Oy\right]$$

is the velocity of the particle in the tube relatively to the moving axes. Let that velocity be v. Therefore by (I.) actual velocity of the particle equals

(v along the tangent to the tube) + (ωr perpendicular on the radius vector).. (II)

To find the actual acceleration of the particle we must take the complete differential coefficient of the last formula. Let F denote

Digitized by Google

the actual acceleration, and f the acceleration of the particle in the tube relatively to the moving axes. It follows from (I.), as before, that

D_t (v along the tangent) $= f +$ (ωv perpendicular to the tangent).

We have still to find D_t (ωr perpendicular on the radius vector). This is easily found, by considering that

D_t (r along the radius vector) = actual velocity = (v along the tube) + (ωr perpendicular to the radius vector).

Therefore clearly

D_t (ωr perpendicular to the radius vector)
= (ωv perpendicular to the tube) + ($-\omega^2 r$ along the radius vector).

Putting these expressions in (II.), we find that F = actual acceleration =

f + ($2\omega v$ along the normal) + ($-\omega^2 r$ along the radius vector)...(III.)

Now F is equivalent to the given forces acting on the particle and the reaction of the tube. Let the given forces acting on the particle be S along the tube, N perpendicular to it, and let R be the reaction of the tube along the normal. S is therefore the resolved part of F along the tube, which by equation (III.) equals

$$\text{Resolved part of } f \text{ along the tube} - \omega^2 r \frac{dr}{ds}$$

And as resolved part of f along the tube $= \frac{dv}{dt}$ we have

$$S = \frac{dv}{dt} - \omega^2 r \frac{dr}{ds}$$

$$\therefore v^2 = \omega^2 r^2 + 2\int ds \text{ S}.$$

Similarly we obtain,

$$N + R = \text{resolved part of F along the normal} + 2\omega v - \omega^2 r^2 \frac{d\theta}{dt}$$

$$= \frac{v^2}{\rho} + 2\omega v - \omega^2 r^2 \frac{d\theta}{dt}$$

which gives R, or the pressure on the tube.

If the tube were to revolve with a varying velocity ω, and also were to have a motion of translation of which the acceleration is α, then we may find, exactly as above, that F equals

$$(f) + (\alpha) + (2\omega v \text{ perpendicular to the tube}) +$$
$$+ \left(r \frac{d\omega}{dt} \text{ perpendicular to the radius vector} \right) +$$
$$+ (-\omega^2 r \text{ along the radius vector}) \quad \ldots \quad \ldots \text{ (IV.)}$$

which formula, as before, enables us to solve the problem both as to the motion in the tube and the pressure on the tube; and it is to be observed that, as every motion of the tube may be resolved in a motion of translation and rotation, it follows that (IV.) affords the solution of the problem of a particle moving in a tube which is itself constrained to move in a plane in *any given manner*.

I will just add that formulæ (II.) and (III.) may be obtained by differentiating twice successively $Q = re^{(\theta+\alpha)\sqrt{-1}}$, where $\frac{d\alpha}{dt} = \omega$.

REPORT ON RAILWAYS.

CAPTAIN GALTON'S annual report to the Board of Trade relating to the railways of the United Kingdom for the year 1858 was lately published. It is much too long for insertion in our columns entire, but the substance of the report is contained in the following extracts, which present a complete view of the existing state of railway communication and of the financial condition of railways:—

"The number of railway bills which came before parliament in the session of 1858 amounted to 113, and the length of new line proposed to be authorised amounted to 698 miles. But of these bills only 73 were passed; and the total length of line actually authorised was 328 miles.

The total length of line authorised by parliament, down to the end of 1858, amounted to 15,659 miles, but of this, 1610 miles have been abandoned by subsequent local acts, or by warrants under the authority of a general act passed in 1847, and consequently there remain 14,049 miles, for which the parliamentary powers which were obtained have not been repealed; of these, 9506 miles were open at the end of 1858, and 4543 miles, which have received the authority of parliament, remain to be opened. With respect to 2473 miles out of the 4543 miles for which parliamentary powers have been obtained, and which have not yet been opened, the powers for the compulsory purchase of the land and the completion of the works have expired. Upon 300 miles out of the 2070 miles, for the construction of which parliamentary powers exist, the powers for the compulsory purchase of the land have been allowed to expire without having been exercised; and this increases therefore the number of miles which it is not probable will ever be made to 2773 miles. The total amount of money authorised to be raised by railway companies by shares and on loan, to the end of 1858, was £392,682,755, of which £325,375.507 had been raised, leaving £67,307,248 to be raised. There are no means of ascertaining how much of this sum appertains to the portions of railway for which the parliamentary powers have expired.

Of the 9542 miles open for traffic on the 31st December 1858, including 36 miles of private railway, the proportion constructed on the narrow gauge, broad gauge, mixed gauge, and Irish gauge, is as follows:—narrow gauge 6352, broad gauge 749, mixed gauge 261, Irish gauge 1180.

The length of new lines opened for traffic during the year 1858 amounted to 426 miles, of which 372 miles were laid with only one line of rails. The length of new line reported to be in course of construction on the 30th June 1858, was 880 miles; of these about 219 miles were opened before the 31st December 1858. The number of persons employed on the 30th June upon the railways in course of construction amounted to 38,546, being on the average 43·79 per mile.

The length of line open for traffic in the United Kingdon on the 30th June 1858, was 9323 miles, and the number of persons employed thereon amounted to 109,329 persons or 11·72 per mile.

The total amount of money raised for the construction of railways on the 31st December 1858, amounted to £325,375,507, which represents an expenditure of £34,243 per mile of railway open. The lines in course of construction amount in length to about one twelfth of the whole length completed and in course of construction, and some portion of this cost per mile belongs to those lines. Of the expenditure for construction, it may be assumed that on an average about 6 per cent. has been for parliamentary and legal expenses, 18 per cent. for land and compensation, 66 per cent. for works, and 10 per cent. for rolling stock. It is worthy of notice, that although the cost of railways in the United Kingdom has averaged £34,243 per mile, viz., £38,779 in England, £27,532 in Scotland, and £15,061 in Ireland, the average cost of lines of railway for which acts have been obtained since 1848, and which are now opened for traffic, has amounted to £10,500 per mile; viz., £12,600 per mile in England; £8700 per mile in Scotland; and £6600 per mile in Ireland. Of the total amount of money raised, £81,683,179 has been raised by loans, £61,854,547 by preference shares, and the remainder, viz., £181,837,781, by ordinary share capital. The preferential and loan capital invested in railways is 44 per cent. of the whole capital, and the interest which has to be paid upon the preferential and loan capital averages 4·63 per cent.; the net receipts on railways give an average interest on the whole capital invested of 3·75 per cent., but the preferential and loan charges reduce the interest on the ordinary capital to 3·06 per cent. It will be seen from the tables that £10,218,249 of additional capital was invested in railways during the year. This is an addition of about 3·2 per cent. to the money previously raised, which was not all invested in new lines of railway; for almost all the existing lines which have had no recent additions to their length have continually increased their capital. It may however be assumed, that so long as the proportion of the net receipts to the capital expended increases in each year, the property is in a sound condition. The net receipts, in proportion to the capital raised, unfortunately show a decrease in 1858 as compared with 1857. Leaving out of consideration the preferential charges in England, the net receipts gave a dividend of 4·26 per cent. in 1857, and 4·03 per cent. in 1858, the expenditure per mile being £38,779; in Scotland the net receipts were 4·09 per cent. on the capital in 1857, and 3·95 per cent. in 1858, the expenditure per mile being £27,532; and in Ireland the net receipts were 4·38 per cent. on the capital in 1857, and 4·22 in 1858, the expenditure per mile being £15,061. This decrease appears however to have been due to temporary causes.

The proportion of the passenger traffic to the whole traffic in England was 43 per cent., in Scotland 36 per cent., and in Ireland 57 per cent. The total number of passengers conveyed on railways in 1858 amounted to 139,193,699, against 139,008,888 conveyed in 1857; the number conveyed per mile of railway open being 14,944 in 1858, against 15,617 in 1857. The receipts from passengers amounted to £10,376,309 in 1858, against £10,592,798 in 1857; the receipts per mile being £1112 in 1858, and £1191 in 1857. Whilst the first-class has decreased 7 per cent., and the second-class 16 per cent., the third-class receipts per mile have increased 18 per cent.

The receipts from goods, cattle, minerals, parcels, &c. in 1858 amounted to £13,580,440 against £13,581,812 in 1857, which represents £1458 per mile in 1858, compared with £1524 per mile in 1857 The total receipts from goods, cattle, minerals, parcels, &c., may be divided as follows, viz.: £7,711,350 was for the conveyance of 25,593,996 tons of merchandise, £4,046,061 was for the conveyance of 48,396,501 tons of minerals, £501,398 for the conveyance of 11,206,110 heads of live stock, and £1,321,631 for the conveyance of parcels, &c. Although there has been

Digitized by Google

on the whole an increase in the receipts for goods, minerals, live stock, &c. in 1858 over 1857, the stagnation in trade caused by the panic had a perceptible effect upon the receipts of the year ended 31st December 1858; in this year there was a diminution of £70,393 in the receipts on account of general merchandise as compared with the receipts of the year ended 31st December 1857; this occurred entirely in England and Scotland. The traffic in live stock also showed a decrease of £22,350 in England and £1097 in Scotland, which was reduced in the general total to £15,960 by an increase of £7487 in Ireland.

The total receipts from all sources of traffic have amounted in England and Wales to 20,244,095*l.*, or 2939*l.* per mile, in 1858, against 20,527,748*l.*, or 3105*l.* per mile, in 1857; in Scotland to 2,536,933*l.*, or 1949*l.* per mile, in 1858, against 2,501,478*l.*, or 2040*l.* per mile, in 1857; and in Ireland to 1,175,721*l.*, or 1041*l.* per mile, in 1858, against 1,145,384*l.*, or 1076*l.*, per mile, in 1857. The aggregate receipts from all sources of traffic for the whole kingdom having been 23,956,749*l.*, or 2572*l.* per mile, in 1858; against 24,174,610*l.*, or 2715*l.* per mile, in 1857.

It would appear that the average working expenses of railway companies, per mile of railway open, have increased in England and Wales from 1352*l.* per mile in 1854 to 1532*l.* in 1858; but that they have decreased in Scotland from 961*l.* in 1854 to 875*l.* in 1858; and in Ireland from 465*l.* in 1854 to 451*l.* in 1858.

The proportion which the working expenses have borne to the receipts has been 50 per cent. in England and Wales as compared with 48 per cent. in 1857; 44 per cent. in Scotland as compared with 44 per cent. in 1857; and 40 per cent. in Ireland as compared with 38 per cent. in 1857; the general average being 49 per cent. upon the gross receipts as compared with 47 per cent. in 1857.

The expenditure appears to be divided as follows, viz., maintenance of way, 16 per cent.; locomotive expenses, including repairs of rolling stock, 37 per cent.; traffic charges, 27 per cent.; miscellaneous, including police and watchmen, compensation, &c., 13 per cent.; rates and government duty, 7 per cent.

In an appendix is given a table showing the proportion which the expenditure bears to the receipts per mile, and per train per mile, on each railway separately, for the years 1855, 1856, 1857, and 1858. From this table it appears as a general result that in England the average receipts per train mile decreased from 70·32*d.* in 1857 to 64·44*d.* in 1858, whilst the expenditure per train mile increased from 32·88*d.* in 1857 to 33·82*d.* in 1858. In Scotland the receipts per train mile averaged 65·04*d.* in 1857 and 64·24*d.* in 1858, and the expenditure in both years was 28·32*d.*; whilst in Ireland the expenditure per train mile appears to have fluctuated with the receipts, the receipts per train mile having been 60·72*d.* in 1857 and 63·1*d.* in 1858, and the expenditure 24·96*d.* in 1857 and 26·3*d.* in 1858. It would appear from these general results that the expenditure on English railways was not reduced in proportion to the loss of traffic.

From the tables relating to the railway accidents which occurred in 1858, it appears that 1 passenger in 5,353,603 has been killed, and 1 in 332,204 has been injured, from causes beyond their own control during the year 1858. The proportion of killed and injured from similar causes to the number who travelled was 1 in 312,794."

Capt. Galton's report concludes with the following remarks:—

"There can be no doubt that the true interests of railway companies are nearly identical with those of the public, both in respect of safety and convenience in railway travelling, and it is to be hoped that each year the railway companies will be led more and more to understand this, and that, whilst doing their utmost to accommodate the public, they will increase their dividends by improved management, and avoid that reckless competition by which so large an amount of money has hitherto been annually wasted."

MILFORD HAVEN.

A report has just been made by Mr. Thomas Page, C.E., relative to the capabilities of Milford Haven. The conclusion arrived at by Mr. Page is, that from the accessible position and other natural advantages of Milford Haven, it is "the best station for mercantile steamers, and the best site for a naval establishment." Mr. Page says:—

"I have had calculations made, showing that the area of the main channel of the estuary of Milford Haven, from the Blockhouse Points to the mouth of Cosheston Pill, above Pembroke Ferry, is at high water 8810 acres; at low water, 6855 acres; at one fathom deep at low water of spring tides, 5354 acres; at three fathoms deep at low water of ditto, 4245 acres; at five fathoms deep at low water of ditto, 2931 acres."

These areas are exclusive of that above Cosheston Pill, at the top of the haven, which gives about 1425 acres at high water, and 741 at low water, with a depth then of two fathoms, where hundreds of steamers or sailing vessels of light draught can lie without touching the ground. The report states that

"The great rise and fall of tide, equal to 26 feet, at Milford Pier, on high springs, gives the port an advantage for the establishment of graving docks, and, in connection with the beaching grounds, for the inexpensive examination of the keels of large iron ships, such as the Great Eastern, without the expense of going into dock.

"It would be difficult to estimate the approximate value of Milford Haven as a port of arrival and departure for large steamers, with reference to the wrecks and casualties which might be avoided by using it, because the destination of the various ships, &c. which have suffered wreck is not stated in the valuable tabular returns published by the Board of Trade; but, taking the south and west coasts of England, the Scilly Islands, and Lundy Island, it appears that the wrecks and casualties during the last four years have amounted, on the south coast, between the Land's End and Dungeness, to 415; on the west coast, from the Land's End to Greenock, to 1148; on the Scilly Islands alone, to 44; on Lundy Island alone, to 44; and on the Irish coast, indiscriminately, to 450. This statement, and a reference to the wreck charts for the last four years, are sufficient to satisfy even an ordinary thinker, that for ships and steamers with valuable cargoes, and especially those of a class now being built, an early port and a quick transfer from the steamer to the railway, afford for passengers, letters, and valuable goods, the greatest safety and the truest economy. This will be more especially exemplified when the Great Eastern commences her voyages; for upon her being kept under way will depend the returns to her proprietors, and upon her easy entering an eligible port the avoidance of risk and delay."

THE LIVERPOOL ARCHITECTURAL SOCIETY.

THE first meeting of the present session of the Liverpool Architectural and Archæological Society was held on the 26th October, when Mr. H. P. Horner, the president of the society, delivered the inaugural address. After some introductory remarks, Mr. Horner said,—

In looking at the points on which passing or recently passed events bear with most interest on our special pursuits, none seems so prominent as that which has been called the Battle of the Styles. In the cabinet, in parliament, in the public prints, in the architectural profession, and among the general public the combat has been and still is waged; and the great field of contest is the space of ground between St. James's-park and Parliament-street, to be devoted to the purposes of new government offices. The arguments advanced are as numerous and varied as the antagonists; and while fitness, association, combination, grouping, progress in art, light, comfort, convenience, and economy are weapons of aggression or defence on either side, a large proportion of those engaged, and some too in very high places, express their opinions with not much more definiteness or precision than he who wrote

> "I do not like thee, Doctor Fell,
> The reason why I cannot tell;
> But this I know, and know full well,
> I do *not* like thee, Doctor Fell."

In simple terms, an immense amount of prejudice has place in this contest on both sides of the question, and for one entering with any strong feeling of interest into it there is great difficulty in coming to an unbiased decision. It is very delicate ground for an architect to tread upon at present, and some may feel that those eminent members of the profession who combined in a strong expression of concurrence with the dictum of the prime minister were stepping further than can be sympathised with by men who wish the matter decided upon its merits, and by the community rather than by the profession.

I think myself that the expression of an honest conviction in the manner in this case adopted is not open to serious objection, although in one light it may appear as a combination in the profession against one of its most distinguished members; still, as bearing on a question of really national moment, the private is lost sight of in the public bearing of the proceeding. None can fail, I think, to feel with the enthusiastic, consistent, and laborious artist whose design is for the time the gage of battle; and whatever view may be taken of the steps by which, under a change of government, the commission came into his hands, all will likewise feel that all that talent and energy could accomplish would be devoted to render the work in its special style worthy of the country and the occasion. Still the question is not one of persons or of feelings, but of art and utility; and to arrive at any fair conclusion an endeavour must be made to free the mind from all trammels of the influence of eminent names, or considerations of private interest, that the question may be fairly put,—What style is artistically, practically, and nationally the most suitable for the intended

Digitized by Google

building? Each of these heads will include many points for discussion, and if not wearisome to you, I will touch on a few of them; and should you think it worth while, I hope no conventional courtesy may stand in the way of your departing from the commonly observed rule of avoiding discussion upon your president's address.

Upon the question of artistic fitness there bear the considerations of locality, as relates to the buildings with which a new one must be grouped; of site, as to the degree in which any style will be satisfactorily displayed; of association, as with ancient or modern institutions, secular or higher purposes, business or academic uses, openness or seclusion; and among many more, last, but not least, absolute relative beauty. As respects the question of locality, we may mention with Sheridan's Critic, that there is much to be said on both sides. The Abbey and the New Palace, the great architectural features of the neighbourhood, are in different phases of the style proposed by the selected architect. Whitehall, the Treasury buildings, and other minor ones, are of the opposing horizontal character. What shall be sought for, contrast or uniformity? The former is most conducive to impressions of life and vigour, the latter of dignity. But liveliness may degenerate into levity, uniformity into monotony, dignity into pomposity.

The preponderance of the great existing features of the spot is certainly towards the pointed and vertical in style, and there being no building of the contrasted horizontal elevation at all equal in note or distinction to those first named, it seems to me that artistic effect in this respect will be best attained by supplying this apparent deficiency, and placing in combined view with the Abbey and Palace towers a stately and imposing pile of well-chosen and carefully-studied horizontal character. The front to the park will indeed be seen grouped only with buildings of the same lineal tendency; but the vastly superior scale of the proposed building to any which there can compete with it must in my opinion give it such pre-eminence, that the question of style can here be but a minor consideration.

The question as to site is in part disposed of by what has been just said, but in some respects it separates itself from the more general one of locality, and particularly as relates to the flatness or the contrary of the ground to be built upon. Here the weight of argument seems in favour of a vertical style, as the site is practically a level one, and the ground in the neighbourhood rises in some directions above it. In such a position we know that a building of vertical character has the better effect, and where an abbey, as at Fountains or Kirkstall, rises with dignity and grandeur from its low, secluded platform, an Italian palace or Grecian temple would appear sunk and lost. The distinct horizontal features of an Italian or Greek design, however, would preserve their vigour of effect on what must, on two sides at least, prove in comparison with the height of the building, narrow streets; and the park front, before mentioned as that where the vertical contrast might, but for the superior mass of the new building, seem most needful, having nearly a western aspect; there cannot, as regards effect of light and shade, be much advanced, I think, in preference for either style above the other. That the principal fronts can in either style be made effective within the range of view that they would command there can be no doubt; and in treating any style, one who is a master of it will see to it that his main features from a distance, and his details on a near approach, shall command each the measure of interest and prominence that they respectively claim as elements of effect. One reason that should be mentioned in fairness for preferring, artistically, vertical to horizontal style in this country seems to me, that in our humid atmosphere and smoky towns the weather-stains combine with and assist the effect of the former, while they jar with the latter and their sunny associations.

Upon the ground of mental association, men will advance opinions as opposite as are their social or political maxims and views. Some will look back with pride to our historical progress, and wish to associate the new structure with memories of our rise in the scale of nations—with the continental victories of the 14th century—with the academic foundations and palatial grandeur of the 15th and 16th, and feel little comparative pleasure in regarding us as the great commercial and colonising nation of the 18th and 19th centuries. Another, holding our modern advances in far more honour than our past history, would associate all with the present; and if a style could be originated embodying in itself the ideas conveyed by the words "ships, colonies, and commerce," that should be the one selected. This is ground on which personal habit, feeling, and opinion have far greater influence than any arguments derived from external facts, and it is hard to name anything which can be likely to move a mind whose preferences are so founded. What strikes myself on this topic is that our present position, habits, and requirements are so much more nearly allied to those of the Italian republics in the days of their prosperity, than to those in which our abbeys, colleges, and all but lost palaces, were raised; that some style assimilating to those which arose under the circumstances of these republics, seems to me far more appropriate for the actual abode of our executive government, than any which derives its interest from associations with an age and with habits so remote from our own as those prevalent under our Edwards and Henries. That our seat of legislature should be allied in idea with that earlier age in which its germ first took root, is another question; and the parliamentary and executive functions are so distinct, that any argument applied to one by no means necessarily affects the other. But in the case of the Foreign Office, the design under discussion seems almost excluded from the ground of national asociation of any kind, belonging, as it certainly does, to the style of Southern Europe rather than any other; nor can I think myself that anything is gained by this exotic choice. And this brings me to the final question in the artistic view of the matter, namely, the comparative merits in point of beauty of the two proposed styles.

It seems impossible, I confess, for the reason just given—I mean the peculiar phase of style selected—to put this question on the general merits of Gothic and Classical architecture; and should we even do so, the question, like that of association, will become all but endless, as regards the varieties of opinion among those who might have to decide. I believe there is a much more general appeal to human sympathies, for some reason which I cannot define, in the vertical than in the horizontal styles; but I confess that I think, in the choice in this instance made, the architect has fallen off from the character of style which would afford him the best ground of competition with the finest Classical designs. The vices, as I must call them, of the selected style are not evaded or subdued to any great extent in the design as I have seen it engraved, but a bold desire evinced to put it in its essentials on its trial on English ground; and I think many supporters must have been lost through this selection. Features there are in the design reminding us of the mediæval buildings of Western Europe; but, to my eye, the design comprises a good deal more of the "Stones of Venice" than I should wish, notwithstanding the security we have in the talent of the author, to see settled in the streets of London.

It is not my purpose to discuss at length the practical questions connected with this subject. As to cost of execution, there is probably little choice to be made, and so John Bull may be satisfied on one material point with him. And the questions of light and access seem also well balanced; but for practical business it seems to me that with modern habits to consult, the complete carrying out of such a style of building for such a purpose may be questionable. Simplicity is most consonant with the routine work of a public office, and simplicity in plan and general treatment is more allied to horizontal than vertical composition. I do not know how far this argument can be safely urged; but I believe many would feel a difficulty in pursuing the necessary duties of such an office in a building so remote in character from that of the prevalent style of our domestic buildings, especially in towns. The national part of the question is in great part contained in the power of association, and as I have said on that head, is, in my opinion, much weakened by the adoption of so decidedly a foreign phase of the Pointed style. The Tudor is essentially English; so is the Lancet style, in its peculiar development. The Geometrical is more general in its bearings, though in the form it took among us before merging in the curvilinear, as for instance in Tintern Abbey, I think it is also essentially English. All of these might have been considered in the claims of style for the building proposed, but all seem to have been discarded; and unless something in the detailed treatment, which does not appear in the general design, should have been intended to bring the work within the pale of English Gothic, there is but little which I think an Englishman as such would desire to have ever before him in a national edifice.

I have thus far ventured to enter into the critical question before us, because I think much suppression of free opinion and much prejudiced comment exist in connection with it. I would not, were it even possible, detract in the smallest degree from the high repute most worthily accorded to the author of the design,

Digitized by Google

but the question is a national one, and as such free for discussion; and so much false criticism has gone forth upon it on both sides, that I desired to show, if I might, how it seemed to me it could be really fairly dealt with. My judgment may be greatly in error, but thus the matter presents itself to me.

Another question of the day, at once a national and architectural one, is that of the suspension of building operations in consequence of the metropolitan strike. Though this happily has not extended, so far as I know, to the provinces, it is a matter of national moment, involving as it does an important principle, and connected as it is with the works in hand by the great contractors of London. The evils attendant on it are beyond calculation; and I cannot myself but feel that they are the more to be regretted, as a spirit of conciliation on either side would appear all that is wanted to bring the matter to a close. The number of workmen out of work is diminishing, but the leaders and chief participators in the movement remain obstinate, and the masters seem little more inclined to be moderate in their requirements for a renewal of engagements. The workmen must ultimately be the sufferers. The contest of capital with labour tells against both, but always most against the workmen. Babbage, in his able work on the 'Economy of Manufactures,' has some very apposite observations on combinations of men against masters, a few of which I should wish to quote to you; they are alike applicable to manufacturers and to the building trade, though the illustrations with which he enforces them are drawn from the former. He shows that when, to guard against the effect of a possible strike, the masters establish a reserve fund—a reserve of material, or charge a percentage on contracts—the effect is equivalent to so much capital withdrawn from the employment of labour to the direct injury of the workmen. Babbage, a very high authority in such matters, says (p. 292):—"The effects arising from combinations amongst men, are almost always injurious to the parties themselves. There are numerous instances in which the public suffer by increased price at the moment, but are ultimate gainers from the permanent reduction which results; whilst, on the other hand, the improvements which are often made in machinery in consequence of 'a strike' amongst workmen, most frequently do injury of greater or less duration to that particular class which gave rise to them. As the injury to the men and to their families is almost always more serious than that which affects their employers, it is of the utmost importance to the comfort and happiness of the former class that they should themselves entertain sound views upon this question." [Further quotations were made from pp. 298 and 299.] At the recent meeting of the National Association for the Advancement of Social Science, Lord Brougham made some observations on this subject well worthy of attention, and which fully support the opinion as to ultimate injury to the workmen which I have just read. [The president then read an extract from Lord Brougham's address at Bradford, bearing on the question of strikes; but as the speech is so fresh in the recollection of the public, it is unnecessary to repeat it.] It is much to be hoped that this question will be seriously taken up by the legislature, and some means adopted which, while securing to every workman a free market for his labour, will secure both workmen and masters from the injurious and sometimes ruinous effects of such combinations. There must be something wrong, and it does not all consist in the evil influence of the mischievous promoters of such steps among the workmen themselves; the mutual confidence which once existed between the employer and the employed bids but too fair to be lost amongst us, and with it one of the greatest stimulants to honesty and perseverance—the prospect of permanent employment among workmen. The immediate claim in which the present strike originated—that of ten hours' wages for nine hours' work—I do not enter into. It is palpably false and absurd, and, as has been clearly shown, must if successful cause a rise of 10 per cent. in the cost of production and of the necessaries of life.

Resuming more agreeable topics, I may notice the increasing number of buildings in our own town of an externally architectural character; some are the productions of long-established practitioners, but some, from time to time, appear from the designs of those but lately in our students' class. The town is greatly enriched in aspect by these accessions to its architectural embellishments, and it is only to be regretted that they should be so much confined for the most part to the great centres of business. The outskirts of the town, except where relieved by the occasional addition of a place of worship or a school, spread out in endless repetition of small houses, with numberless bow windows, each looking into its neighbour, and each adding its quota to the wearisome monotony of the general effect. As regards the business buildings just alluded to, it is to myself a cause of regret that the utilitarian spirit which pervades our community leaves so little scope for the development of architectural character internally in proportion to the external. Would it not be well for all who feel the really artistic character of our profession to aim as much as may be at conquering this, and even at some little sacrifice of outward adornment to endeavour to secure a greater measure of architectural consistency, and save these buildings from partaking, as without this they may seem to do, of the pretentious, self-obtruding, puffing character of the day. I know the difficulty in many cases, but it is worth trying for, as all will acknowledge the disagreeable impression caused by passing from an ornate, highly-finished outer face to a bald interior.

Another question worthy consideration is, I think, that of improving the style of our ordinary fences to inclosures of ornamental ground. When not of iron (and then they are frequently of the most inartistic character) they are too frequently the merest paling, and that too in neighbourhoods where finish might be reasonably looked for. One of the senior members of our society some time ago called attention to the variety and ingenuity of design in ordinary wooden fences displayed by the architects of Northern Europe. We might worthily emulate them in this, and save from monotony, and often from sheer ugliness, suburban roads, rendered in other respects agreeable by their shrubberies or ornamental woods. Another point in which utilitarian instincts seem in danger of invading our art is in respect of our roofs, many of which are treated as if, the building being brought up to the square, the form of its covering was a matter subject only to economical consideration. This is a great error surely, as the skyline of a building is no mean element in its characteristic effect, nor need any material departures, according to my own experience, be made from the most economical form to insure a due measure of this element of effect. I address, of course, chiefly the young members of our profession, but feeling myself how much the consideration of simple relative cost influences design, I should wish for you as for myself that we should endeavour so consistently to distribute the funds at our command over all the parts of a building that, without poverty of effect anywhere, uniformity of treatment may secure architectural effect. One of the most striking buildings recently completed in this county and neighbourhood is the Roman Catholic church at Lancaster, by our member, Mr. Paley. He is to be congratulated, I think, on a very successful and original treatment of his subject, and on contributing, in the tower and spire, one of the happiest modern architectural features to the embellishment of our northern counties.

An important accession has been, in my opinion, gained to our architectural knowledge in the development by Mr. Lloyd of a consistent and very refined rule of proportion discovered in the structure of the Parthenon, and explained in a paper read by him before the Institute of British Architects. (See *C. E. & A. Journal* for September, p. 289.) Most of my hearers will have read this paper, I doubt not, and I will not further dwell on it than to say that it seems to open the way to what has been long desired—a field for original treatment of Grecian architecture, and a release from the monotony of constantly repeated imitations of the details of the Parthenon and Erectheum, without much reference to their general proportions. I heartily commend the subject to the study of our younger and more leisurely members.

I have long thought that a large field lay open for the exercise of very original designs in the use of the great Roman feature, the arch, in combination with graceful mouldings founded like the Greek on the conic sections. Italian combinations of feature would suggest themselves in such a mode of design, and I believe very happy effects might result.

An apparently exceedingly simple mode of obtaining any variety of the sections by the aid of light lately occurred to me, and led me again to think of the subject I have named, and it is a matter of some surprise that so very few instances of such a combination of characteristics as I have hinted at should be found among the designs of English architects. Among the German artists they are not uncommon.

Not much of antiquarian interest in this country has been developed, so far as I can learn, during our recess. The Roman remains at Wroxeter still excite attention, but seem rather to disappoint the expectations at first entertained on their discovery.

Digitized by Google

The Roman villa at Carisbrooke has been thoroughly opened, and it is proposed to roof it, a step indispensable to its preservation.

The care bestowed in this country on most of what we retain of antiquity forms a happy contrast to some others, where, as was some time ago mentioned, the finest Roman remains are ruthlessly destroyed for the mere value of the material. A work allied to some of those executed under Roman rule has just been inaugurated by Her Majesty the Queen in Scotland—that for supplying the important city of Glasgow with water. The result seems highly creditable to the energy and skill of the projectors and their engineer.

With the rapid growth of population and spread of building in England, it behoves all who have influence or opportunity to exert themselves in the cause of antiquarian conservation; and I trust when, as it is to be hoped early, the spacious museum rapidly advancing to completion in our town is opened to the public, a good portion of room will be devoted to national and local antiquities.

In the kindred profession of engineering, our country has to lament the recent loss of two very distinguished men, and both bearing names honoured in a previous generation. It is difficult to over-estimate the deprivation to practical science of two such men as Stephenson and Brunel, and without instituting comparisons, which so soon after their departure from this life can scarcely be fitly made, we may say that, for boldly meeting and overcoming the great physical difficulties with which in their high professional work it was their constant lot to combat, we must look far and wide before we can name any who have so greatly contributed to the arts of civilisation and the promotion of human intercourse and traffic.

In our own profession I am happy to believe that no eminent name has been lost to us since we last met here, and long may it remain so; but let us all remember that life is short, and that we each, in a professional as well as a moral sense, have our work to do; and let us endeavour that, in an honorable, humanising, and useful pursuit, the members of the Liverpool Architectural and Archæological Society shall not in future more than in time past be behind their fellows, or their association fall short of its original and declared aim.

NEW SECTIONAL DRY DOCK AT JERSEY, U.S.

The new dry dock now building and soon to be finished at Jersey, U.S., will afford the means of making repairs on large vessels lying in the western harbour of New York without towing them around the Battery through the crowded channel of the East River, along the shores of which all the large docks are now situated. It will consist of five separate sections, each 80 feet long and 35 feet wide, thus making the dock about 180 feet long and 80 feet wide when ready for use. The extreme height is 28 ft. 4 in.; the opening for a vessel is 61 ft. 4 in. wide at the bottom, 64 feet wide at the top, and 19 ft. 6 in. in height. At midships two water-tight bulkheads, built of 6-inch yellow pine plank and edge fastened, divide the sections into three parts, forming two great tanks in each, and thus securing the means of keeping the dock balanced while taking up a ship. The tanks are built up quite to the top of each section at the ends.

The sections are built with two side and three middle longitudinal trussed sections of framing, with sills, beams, braces, posts, knees, upright side timbers, &c. The side trusses have oak sills composed in two pieces each—the outside piece 9 inches by 16 inches, rabbetted, with a 9-inch side up; and the inside piece 20 inches by 12 inches, with a 12-inch side up. The beams are oak made in three pieces—the inside piece 12 inches by 12 inches; the outside piece 9 inches by 8 inches, with a 9-inch side up; and the top piece 14 inches by 10 inches. The corner and inside posts (two of each) erected upon these sills are oak, 12 inches by 12 inches, and rabbetted for planking. The plates put on the top of these posts are yellow pine 12 inches by 8 inches. The upright side timbers are oak, about 18 inches apart for planking to; they are framed into the sills and beams by sinking into the sill and boxing them into it; the long posts that extend up to the top plate near the side of the dock are tenoned into the plate. There are four oak braces to each truss, 14 inches by 10 inches, abutted to the top, and sunk into the sill by three abutting toes. The work is thoroughly bolted at every joint and crossing.

The middle trusses have yellow pine sills 12 inches square; the posts of same wood, and same size, four to each truss section, are framed into top plates with tenons 6 inches long and 2½ inches thick (draw-bored and pinned), and also into sills with mortices and tenons 5 inches long and 4 inches thick; they are likewise framed to angle deck timbers by halving together, and are bolted with two 1¼-inch bolts at each such connection. The four abutting braces in each truss are of yellow pine, framed and fastened as in side trusses.

The plates on top of end tanks, as we may term the deep space at end of sections, are yellow pine, 12 inches by 8 inches. The keel timbers, or top beam of trusses, are yellow pine 14 inches by 10 inches. Long end braces of yellow pine, one pair to each truss, 10 inches by 8 inches, are framed from tank girts to truss sills, and well secured. The deck beams are yellow pine 8 inches by 8 inches, framed with tenon and mortice to the beams of side trusses, and bolted to keel block timbers: the floor timbers are yellow pine 10 inches by 8 inches, boxed and tenoned into sills of side trusses—four of them in each dock section are 14 inches by 10 inches, and all are strongly bolted to the truss sills.

Four intermediate strut framed sections are placed between the five truss framed sections above described—sills and plates of yellow pine 10 inches by 8 inches, and fourteen 8 inches by 8 inches upright struts, framed together by mortice and tenon, and bolted to floor and deck timbers. There are three cross sections of bracing between floor and deck to strengthen each dock section athwartships—yellow pine sills 10 inches by 10 inches and braces 10 inches by 8 inches (two to each sill), all securely fastened in place. The deep tanks on each end of the dock sections are strengthened by five pairs of girts connected by cross-pieces—girts 8 inches by 8 inches, cross-pieces (five to each pair of girts) 6 inches by 5 inches. The upright timbers for these end tanks are yellow pine 9 inches by 7 inches framed to sills and plates by tenon and mortice. There are thirty-two knees in each dock section for securing the bottom framing.

The planking of the floor, the outside of the end tanks, and the deck, is yellow pine 4 inches thick; the planking of sides between floor and deck is 5 inches thick, and the remainder of the planking 3 inches thick. The bottom planking up to the deck is square fastened with 1½-inch locust treenails, and above the deck the planking is cross-fastened with treenails and spikes. The planking is well caulked with oakum and payed; and the dock below deck is sheathed with 1½-inch white pine.

Engine located upon the top of the middle dock section: diameter of cylinder 12 inches; stroke 36 inches; bed-plate 16 inches deep; fly-wheel 12 feet diameter; shaft 7 feet long, with two pillow blocks—bearings 8 inches long. Bevel wheel on shaft 24 inches diameter; working into one of same size on the intermediate shaft, which is 4 inches diameter and 10 ft. 8 in. long, with 6-inch bearings. Bevel wheel to work into another on fly-wheel shaft; one bevel wheel 24 inches diameter, 6 inches face, to work on a shaft passing down into the dock, provided with coupling clutch; and one spur wheel 28 inches diameter, of pitch line, 6 inches face, to work the main shaft. The main shaft extends across the five dock sections on each side of the dock, to work the pumps. On the engine section, main shaft is 2½ inches diameter and about 32 feet long, made in two pieces and supported by five pillow blocks. One spur wheel 28 inches diameter, 6 inches face, works into another or intermediate shaft, provided with coupling clutch. One pinion 21 inches diameter, 4 inches face, works pump shaft—main shaft on other dock sections of same size and length made in two pieces but supported by four pillow blocks; and one pinion works pump shaft same as above.

Two upright shafts 3 inches diameter, about 20 feet long, and one cross shaft 3 inches diameter and about 71 ft. 9 in. long, give motion to the machinery at the opposite side of the deck; they are provided with bevel wheels 24 inches diameter and 6 inches face, and pillow blocks 10 feet apart and 6 inches bearings. The cross shaft is coupled with sleeve couplings and passes through stuffing boxes on the inner sides of dock—sleeve couplings about 10 inches long; the couplings for main shaft from one dock section to another are with universal joints and sliding sleeves 3 ft. 6 in. long—from centre to centre of joints is about 5 feet.

The pumps are placed 6 feet apart, and will be worked by cranks fast on a shaft 2 inches diameter; cranks are provided with three pin holes to allow stroke of pumps to alter from 24 to 27 and 30 inches. Spur wheel on pump shaft 35 inches diameter, of pitch line, 4 inches face, works into pinion on main shaft;

Digitized by Google

pumps are 12 inches diameter, and 3 inches stroke—upper part of brass with brass bucket and rod and rubber valves, the lower part of cast-iron with brass valve seat in chamber and rubber valves—chambers provided with manholes to get at the valves and replace them. Four pumps are placed in each dock section; the connecting-rods are about 16 feet long with a fork at lower end to take hold of the lengthened pump rod, and they work with a strap and key on upper end. Two water valves of 12 inches diameter, are fitted in outside of dock in each section; they are composition metal, and worked on upper deck of dock by a rack and pinion.

The boiler is of locomotive style, about 17 feet long, and the cylindrical part 3 ft. 6 in. diameter. It is intended the engine shall make about fifty revolutions and the pumps thirty per minute. There will be about 700,000 feet of wood materials used in the construction of this dock; its builder is Mr. Beede, of Jersey, who completes the work by contract, machinery included, for about 53,000 dollars. The owners of the dock described are the Hudson County Dry and Wet Dock Company, of Jersey City.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Twenty-ninth Annual Meeting, held in Aberdeen, 1859.

(Continued from page 375.)

On the Progress of Steam Navigation at Hull.

By JAMES OLDHAM, M.Inst.C.E.

For generations past Hull has been noted for its Greenland and Davis Straits fishery, and for many years this has constituted the chief feature of the port. Within the last two or three years steam has been put into successful requisition to aid the dauntless and hardy mariner in the pursuit of this hazardous calling, and now we have several screw steam-ships employed; and although some of them are fitted with comparatively small power, they have proved to be possessed of great advantage in the service, and in some instances satisfactorily to the owners. We have had two descriptions of steam-vessels employed in the fishery; the first, the old wooden sailing ships, which had been engaged in the service for some years, but which were afterwards fitted with screw machinery and auxiliary steam power. The second, iron-built ordinary screw steam-vessels; but which proved, I believe, almost a total failure: the material of which they were built and the want of strength for such a purpose proving them altogether unfit to contend with the severity of the climate and rough encounters with the bergs and fields of ice, some becoming total wrecks, while others returned bruised and rent, and were with difficulty kept from sinking. A question here arises, how far iron ships are calculated to bear the severe frosts of high latitudes, and whether wooden-built vessels, with all their defects, are not the best adapted for encountering such a climate? The screw steam-ship which was first sent from Hull, or any other place, to the fishery as an experiment, was the Diana, timber-built, 355 tons and 40 horse-power, high pressure, the property of Messrs. Brown, Atkinson, and Co., of Hull. This vessel had been some time engaged in the fishery as a sailing ship; but her spirited owners, thinking an important advantage could be gained, determined upon the adoption of steam power, and at once had the Diana fitted for the spring of 1857 by Messrs. C. and M. Earle, who put in the engines, and made the screw to lift out in case of need. The experiment fully answering their expectations, Messrs. Brown, Atkinson, and Co. bought the Chase, a fine American built ship of immense strength, and of 558 tons. She was fitted by Messrs. Martin, Samuelson, and Co. with condensing engines of 80 horse-power, and despatched to the fishery in the early part of 1858, and with good results. By the application of steam ships in this service can now make a voyage first to Greenland, and afterwards to the Davis Straits. In the commencement of this year several ordinary iron screw steamers were despatched to Greenland, viz., the Corkscrew, Gertrude, Emmeline, and Labuan: the latter only of this class, which is the property of Messrs Bailey and Leetham, had any success; but in consequence of her great strength and peculiar form, succeeded in a tolerable way; the others were much damaged, and, as I have already remarked, returned in bad condition. The Labuan is 584 tons burthen and 40 horse-power.

The next point of interest connected with the steam-ships of the port of Hull refers to alterations made in some of the vessels. The Emerald Isle, a paddle timber-built ship of 1835, the property of Messrs. Gee and Co., originally 135$\frac{6}{10}$ long, lengthened 35 feet, with a gain of 14 inches draught of water, and an increased capacity for 100 tons dead weight. The Sultana, iron screw steam-ship of 1855, the property of the same house, originally 150 feet long, lengthened 30 feet, with a gain of 10 inches draught of water, and an increased capacity of about 100 tons. It is interesting to observe that in both cases we have no diminution of speed through the water, and that both vessels are improved as sea-boats. Daily experience teaches the advantage gained, in almost every point of view, by ships of great comparative length. The iron steam-ship Lion, of Hull, formerly a paddle-boat 249 feet long, but now converted into a screw steamer by her owners, Messrs. Brownlow, Lumsden, and Co., under the direction of Mr. Anderson, their engineer, exhibits the great advantage gained by the alteration. Her register tonnage is 690, and the total tonnage 1014. She was formerly fitted with steeple engines of 350 horse-power, and had four boilers, two before and two abaft the engines; but these were substituted for direct action engines of 150 horse-power, and two of her old boilers replaced, and by this alteration a clear length of hold in midships of 23 feet is gained. She required before the conversion 650 tons of coal for a St. Petersburg voyage, and consumed 30 to 40 cwt. per hour; but now 350 tons for the voyage, and a consumption of 20 cwt. per hour. By the change of machinery about 130 tons of dead weight is removed from the ship, and she is now able to carry 400 tons more cargo. Her speed is also improved considerably; before the alteration, when drawing on an average 14 feet, the rate was six knots and a half, but since the change, when drawing even more water, they can steam eight knots. Thus throughout a saving in almost all departments of the ship, and other advantages, have been effected by this important change. During the last two years many fine steam-ships have been built in Hull, and others are in process of building for English and foreign service by Messrs. Brownlow, Lumsden, and Co., Messrs. C. and W. Earle, and Messrs. Martin, Samuelson, and Co. The last-named firm are making rapid progress in the building of two large paddle steam-ships for the Atlantic Royal Mail Steam Navigation Company, of the following dimensions, power, &c.—

	Feet.
Length between the perpendiculars	360
Beam moulded	40
Depth	30
Tonnage, builder's measure	2860
Nominal horse-power	800

These ships are to have three decks, and to be fitted fore and aft for passengers. Speed through the water, twenty miles per hour. They will be of immense strength, and their build and form such as to insure their becoming fine sea-boats.

Since the meeting of the British Association at Dublin, considerable advance has been made in London and other ports in the application of superheated steam, and, I believe, with great success and satisfaction in the results; Hull, however, before taking a decided step in this important discovery, is anxious to see and adopt the best mode of the application of the principle, being assured that in every onward movement it is better "to make no more than good speed." Some attention has been paid to the consumption of smoke in the furnaces of our steam-vessels, and with a considerable amount of success I may here mention the mode of Mr. Ralph Peacock, of New Holland, Hull, for which he has taken out a patent. It consists of a double furnace-door, the chamber or space between the inner and outer surfaces being five to six inches in width. The inner plate is perforated very full of small holes, and in the outer plate a revolving ventilator is inserted, which is on the principle of that invented by Dr. Hale to supply close places with fresh air. The apparatus is in use on board the Helen Macgregor, one of Messrs. Gee and Co.'s. large sea-going steam-ships, and has given very general satisfaction, for by the report of the chief engineer, Mr. McAndrew, a saving of fuel is effected, and the steam better sustained. Another great advantage, as reported by the master, Captain Knowles, derived from this invention is, that on running before the wind they are never now annoyed and endangered by a dense cloud of smoke in the direction of the ship's course, which, particularly at night time, creates so much risk of collision. This apparatus is also in use on board several other steamers, viz., the Yarborough

Digitized by Google

and Grimshaw, belonging to the Anglo-French Company, the Albert, of Hull, and also a number of river steam-boats. I have great pleasure in noticing also an improvement introduced on board the Queen of Scotland, another ship belonging to Messrs. Gee and Co., for the same object, by the chief engineer, Mr. Smith, and having furnaces of ample capacity, answers the purpose in a most satisfactory manner. Mr. Smith's mode consists simply in keeping a few inches off the front ends of the bars quite clear and clean from side to side of each furnace, thus admitting at the right place a sufficient amount of air. The report of the master, Captain Foster, is very satisfactory. I have witnessed also the effect of this mode on the furnaces of stationary boilers with perfect results.

I have now to refer to the application of Silver's Marine Governor, as applied by Mr. John Hamilton, of Glasgow. Several of these ingenious and efficient instruments are now in use on board steam-ships in the port of Hull, giving the highest satisfaction. They are so sensitive in their action, that the slightest pitching motion is at once indicated, and the steam admitted or excluded as the case may be. By the use of this governor the full power of the engines is in immediate and constant requisition, producing the effect of saving of time, saving of fuel, and preventing of accidents by what is termed racing and otherwise. The ordinary mode, in the absence of the governor, is for the engineer in stormy weather and heavy seas continually to stand at the throttle-valves, or, to save himself this trouble, to throttle the engines; and thereby when the full power of the engines is most required, it is frequently reduced to one-half or less, and consequently there is occasioned a loss of time on the voyage, and the risk of falling on to a lee shore.

On a System of Moving Bodies. By ALEXANDER STEPHEN WILSON.

Theorem.—If in a system of bodies moving in a straight line in free space one part of the system be made a fulcrum for projecting another part, either in a plane perpendicular to the motion of the system, or parallel to that motion, such projection shall not alter the rate of motion of its centre of gravity, nor change that centre's line of motion; and the parts projected, when they have described the resultant of the forces by which they are moved, shall be again brought by the unvarying motion of the centre of gravity, as near as before projection, to the centre of the system.

Let ABCD (Fig. 1) be a system of bodies, moving in the line MNO. Complete the parallelograms EF and FG, and also HN and NL, and draw the diagonals DD′ and D′D″, and likewise MK and KO. If from M the part D be projected in the line DE, the part ABC shall likewise be projected in the line MH; and the two projected parts shall first be carried beyond the line of motion MNO to D′ and K respectively, and next to O, or into the relation they occupied before projection.

FIG. 1.

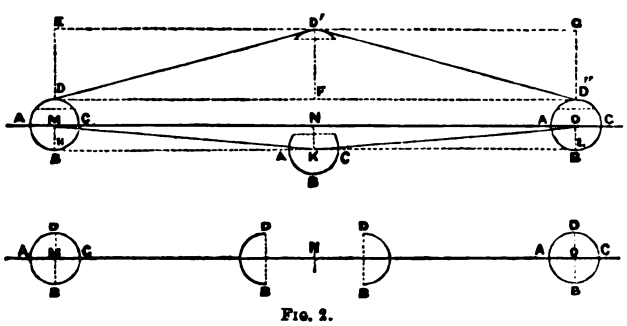


FIG. 2.

For if with the system at the point M the part D be projected in the line DE, perpendicular to the line of motion of the system, the remaining part ABC shall by reaction be projected in the contrary direction, or in the line MH. But it is assumed that the system has a motion in space much more rapid than the motions of projection. And, by the principle of the parallelogram of forces, the resultant of DE and DF is DD′. And the resultant of MH and MN is MK. When, therefore, the system has moved to the point N, the part D will be at D′; and the part ABC at K. And because action and reaction are equal and contrary, the reciprocal projection of the two parts will leave the centre of gravity of the system unaffected in the point N, at a distance from either of the displaced parts determined by its relative momentum; while the ratio which the respective forces DE and MH bear to the force MN or DF, determines the limits of projection FD′ and NK. But it is involved in the second law of motion, that bodies must move in the line of the force by which they are moved. Now, the parts at D′ and K have been projected out of the line MNO, by which these parts are virtually moved, and to which they are as much connected at N as they were at M. For, since it is the momentum of the system which enables the projecting force to act, it is the motion of the system which impels the parts into the line of that motion. This force therefore at N, where the resultants of projection and translation in space terminate, must bring the displaced parts again down to the centre of gravity, or towards the line of the force by which they are moved. The motion of the system being the force which opposed the separation of the parts, is, necessarily, a force drawing the parts again together; or, more properly, drawing each of the parts into its own line of motion. But if the force represented by NO draws the projected parts into the line of that force, then because the part D′ is moving in the line D′G, and the part ABC in the line KL, the parts are respectively acted on by forces moving parallel to D′F and D′G, and to KN and KL; and the lines into which these forces may be respectively resolved are D′D″ and KO. Therefore, at the point O, the motion of the system has brought the projected parts again as near to the centre of that system as before projection.

Again, let ABCD (Fig. 2) be a system of bodies moving in the line MNO with a uniform rate of motion. Let the system be separable into two equal parts in the plane BD; and let a force of projection be introduced at M, acting parallel to the motion of the system. If the two parts be separated as at ABD and BCD when the system arrives at N, these two parts shall be again united by the motion of the system when the centre of gravity arrives at O.

For if the act of projection takes place at M, it is clear that in the one part the force of projection will be added to the motion of the centre of gravity, and in the other, subtracted from it; so that when that centre arrives at N, one part of the system will be at ABD and the other at BCD. The half of the system ABD will be made to move slower than the uniform rate of the centre; and because it was the reaction or resistance to increased motion of the other half, BCD used as a fulcrum, which enabled the force of projection to lessen the motion of ABD, the amount of motion subtracted from ABD must be precisely the amount added to BCD; and therefore, by the equality of action and reaction, BCD will move as much faster than the centre of the system as ABD moves slower; and the centre will thus remain unaffected. But the two parts thus mechanically separated are still dynamically connected with the centre of motion as much as before separation. The position of the two parts at N are the total resultants of the force of projection, combined with the uniform motion of the centre. The force of projection, in respect of both parts, is opposed by a contrary force. ABD in coming from M is moving slower than the motive force of the system; but, being part of that system, the motive force is constantly acting against the retarding force of projection, and therefore constantly accelerating this part, until at ABD it momentarily possesses the same rate as the centre N. Conversely, the part BCD is, during the same time, moving faster than the centre of the system, which consequently necessitates its retardation, because the slower motion of the centre of the system is acting against the force of projection, until at BCD this part likewise passes through the point of equal motion with the centre N. But at N, the part ABD possesses the uniform rate of the system, *plus* the force of acceleration which brought it up to that rate; and the part BCD possesses the uniform rate of the system, *minus* the force of retardation which brought it back to that rate. Therefore, at N, the relative motions of the parts will become reversed,—ABD will now move faster than N, and BCD slower, because ABD possesses the rate of the system, *plus* its acquired force of acceleration, therefore it must move faster than N; and, because BCD possesses the rate of the system, *minus* its acquired force of retardation, therefore it must move slower than N. But because ABD, after passing its position at N, is moving faster than the centre of the system, and BCD slower, they must meet in the point O. And because the part ABD will then have just as much more motion than O, or than the centre of gravity, as BCD has less, the uniform rate of the centre of the system will

Digitized by Google

still remain unaffected. For at every moment, the motions of the parts added together, the one being positive and the other negative, give the normal motion of the system. Therefore, the progressive motion of a system of bodies will cause the parts of the system separated in a line parallel to that motion again to meet.

Corollary.—It follows from these two cases, which are susceptible of an infinite variety of combinations—depending upon the angle which the plane of projection makes with the plane of motion—that since it is the motion of the system which brings the projected parts together, the force of projection displacing the parts is a force exerted, not to overcome any inherent attraction in the parts, but to change the direction of motion in these parts. Therefore, if the system were at perfect rest, there could be no projection, since there would be no motion to create a fulcrum. Also, the faster a system is moving, the greater will be the weight or momentum of its parts, since the weight is not an inherent quality of matter, nor a result of any inherent power in matter, but simply a result of motion. It likewise follows that, as the planets are systems of moving bodies, the motion of projectiles on their surfaces, and the whole phenomena of weight—differing in value, as they must do, with the respective rates of each planet —are solely referrible to the motions of these systems. From which it is easily deducible, that *the motion of the terrestrial system is terrestrial gravitation.*

Robertson's Patent Chain Propeller. By PETER SPENCE.

At the request of the patentee and several gentlemen engaged in bringing this invention into practical operation, I have undertaken to give a short description of it to the Mechanical Section of the British Association.

It is well known that great efforts have been made to adapt steam power to the conveyance of both passengers and goods on canals, but although the failure of most of these efforts is apparent, from the fact that on a very few canals is it at this moment employed, yet there seems no reason to doubt that if steam power can be made to suit itself to the peculiarities of canal navigation, it will be found, as in every other department of mechanics, the cheapest and most convenient agent.

In 1831, when the first efforts seem to have been made to employ steam power on canals, Mr. Fairbairn, who was then engaged in an extensive series of experiments by which much valuable data was elicited, recommended for this purpose a peculiar form of steam-boat with paddles in the stern; but however well these boats might otherwise have fulfilled the design, the surge from every form of paddle steam-boat was no doubt the fatal barrier to their adoption When at a later period the screw was adopted as a propeller, this seemed to meet the difficulties of the case, and screw-propelled boats have to some extent been adopted and are now in use: but even the screw has been found only applicable to the few canals which are of considerable depth; and in these the danger always exists of a disturbance producing a disintegrating effect on the sides and bottom of the canal, and where as in the majority of canals the depth does not exceed 3 to 4 feet, the working of the screw is found to be altogether impracticable.

The invention of Mr. Robertson fully meets and obviates these difficulties arising from the use of both the paddle and the screw, while it possesses advantages in obtaining the full effect of the power applied, which are apparent at once. In whatever mode power is applied to the propulsion of vessels in water, by the paddle or screw, there is a great loss of power, only a part being productive, and the remainder wasted. For example, when the paddle is just entering the water on the one side, and leaving or emerging from it on the other, the powers expended in these actions only neutralise each other, and contribute nothing to the propelling of the vessel. So great is the loss of power in some circumstances, that one authority gives the following example:—Suppose a boat propelled in a stream, the power being affixed or applied to a cylinder on which a rope is wound, the other end of the rope being attached to a fixed point at some distance up the stream or on shore; and that the power is afterwards applied by paddles in the stream: it will, he says, take three times the motive power in the latter case that it does in the former to propel the vessel at the same speed. This, I think, must be an exaggerated estimate; but it clearly proves the great loss of power in certain cases, and the probability that it is considerable in all.

The peculiar principle of Mr. Robertson's invention is, that he applies the power by dragging the vessel from a fixed point, and its great ingenuity is, that the fixed point is at the same time a moveable one,—a constantly fixed point in relation to the power exerted by the engine in propelling the vessel, and a constantly changing point in relation to the course on which the vessel is being propelled. The construction of the propelling apparatus is as follows:—At or near the bows of a boat, say 70 feet long, is placed a steam engine, the main shaft of which crosses the bows of the vessel at or about the level of the deck; a fixed pulley is attached to each end of this shaft, these pulleys projecting over the sides of the vessel; they are 3 feet or more in diameter, and on their periphery have a hollow or groove to receive the chains which are to run over them; they are also so constructed as to take a firm hold of the chains as the power is exerted in dragging the chains over the pulleys. On the other or the stern end of the boat are two pulleys, also projected over, one on each side; these are loose, so that the chains merely run over them. Friction rollers are also placed along each side of the vessel, to carry the chains as they pass from the stern to the bows of the vessel; the chains, which are endless, pass or are dragged over fixed pulleys at the bow of the vessel, and falling down lie along the bottom of the canal, and thus become the fixed point or lineal anchor on which the power acts; the action of the engine in dragging the chain over the loose and fixed pulleys being necessarily to drag or propel the boat forward. Every yard of the chain passed over the pulleys representing a yard of space that the boat has progressed in her course—the fixed point or length of chain lying at the bottom of the canal still remaining the same, what is taken up at the stern being replaced by exactly the same length deposited at the bow. The speed of the vessel is thus exactly equivalent to the speed and size of the driving pulleys, unless, indeed, there should be any slip of the chain in passing over them, and this in practice is easily prevented, and is again exactly measured by the velocity of the chain, unless there should be a slip of the chain along the whole length over the bottom of the canal, and this, of course, is a mere matter of the weight of the chain. In repeated trials which have been made before thousands of spectators (and in more than one of which the writer was on board), in a boat 70 feet long and 7 feet wide, the chain used was only 20 lb. per yard, or 40 lb. per yard for the two chains, 22 yards of double chain being always at bottom; this gives a weight or resistance of 880 lb. in this case as the fixed point. From the data ascertained by Mr. Fairbairn, that in tugging vessels the average pull of a horse was 94 lb., the fixed point in these trials would exceed nine horses' power, and an engine power of nine horses could therefore be exerted without the chain slipping over the bottom of the canal. The speed attained ranged from 4 to 6 miles per hour, and nothing more was attempted at that time; the motion was easy and regular, the facilty for starting equal to either screw or paddle, and the power of stopping quite peculiar. The moment the engine stops she drags at anchor, and the momentum is absorbed before the vessel has proceeded one-half of her own length.

The weight of chain can be doubled or quadrupled without inconvenience, and the capability of using increased power to any extent be afforded as required. The weight of chain when increased does not materially increase the loss of power, as the power expended in raising the chains at the stern is neutralised by the weight of the falling chain at the bows, the only loss of power being the friction on the pulleys and friction rollers as the chains pass from stern to stem of the boat above water, and that must be so trifling as not to merit calculation. The invention is not limited in its application to canals, but is suited to rivers where occasional shallowness may render either paddles or screw useless, or where a strong current would prevent any amount of power being got except at an enormously increased and therefore impracticable speed. No additional speed, but only an additional power would be required by the chain propeller to stem the strongest current; and however shallow, if the boat will float the propeller will work.

It is almost needless to add that the working of the chain gives rise to none of that commotion in the water that constantly attends the working of both paddles and screw; the chains rise and fall without the least perceptible agitation of the water, and even the ordinary wave from the bow of the boat is cut in pieces by the falling chain and reduced to the merest ripple.

Digitized by Google

THE ARCHITECTURAL ASSOCIATION.

THE opening meeting of the Architectural Association, for the session 1859-60, was held on the 28th October in the rooms of the Architectural Union Company, Conduit-street, Hanover-square. The president of the association, Mr. Penfold, being in the chair. The annual report was read, and furnished highly gratifying evidence of the increasing usefulness and prosperity of the association, which now numbers 130 members. The syllabus of papers to be read during the present session contains some very interesting subjects. It has been determined to award a premium for the next series of sketches produced by members of the Class of Design, and also to offer a prize for the best essay contributed during each session on a selected subject. The subject chosen for the present session is the important one of "Street Architecture,—its proper treatment."

The preliminary business of the meeting being disposed of, Mr. PENFOLD delivered the opening address. After some introductory remarks, he said,—

"The past must ever be the teacher of the present, and with your permission therefore I propose just to give a passing glance at such few noteworthy occurrences as may have attracted our attention during the last year.

In matters architectural we slowly but surely progress, and year after year we have to chronicle the completion of some works of importance. In the metropolis alone, among those of the year we may mention two or three theatres, of which the Adelphi deserves special notice; some public buildings; and many good specimens of street architecture in our insurance offices and mercantile establishments; several churches, among which we may point to St. Margaret's as a splendid specimen of ecclesiastical decoration; and last, though by no means least in the effect it is likely to have on our profession, the building in which we are now assembled, carried out under the superintendence of two of the oldest members of this association.

In the country we may add to our list, the new Museum at Oxford; and public buildings and churches in many of our principal towns, particularly noting the church at Doncaster; besides several large works carried out by government, such as the hospital at Netley, and extensive barracks at Aldershott, and other places. And while on the subject of government works, I may pause for a moment to ask, why it is considered requisite that so many of these matters should be carried out by Engineer officers, and so few by architects, who are surely capable of doing as well, as has been often proved in competitions and on other occasions: in fact, we know a great part of the real work is done by assistants and draftsmen who have for the most part been regularly educated in the profession; and it would certainly seem rather the province of a civil architect than of a military engineer to carry out such buildings as hospitals and barracks, where what I may call domestic convenience is of so much importance in connection with economy of construction.

Among the works which indirectly exercise a considerable influence on our profession should be mentioned those that propose to afford a greater facility of access from one part of the metropolis to the other,—such as the new streets in Southwark and elsewhere; the new Westminster-bridge; the Charing-cross, the Metropolitan, and the Victoria Station railways, as also the works in connection with the main drainage.

Competitions too have had their fair share in the events of the year. The Manchester Assize Courts, Spurgeon's Tabernacle, and other intended buildings, have called for the display of considerable talent; while Englishmen have carried off prizes in competition for a theatre at Rio Janeiro.

The Foreign Office question still drags its slow length along. I took occasion to remark last year that the Battle of Styles seemed likely to be prolonged and doubtful in its issue; and so it has proved,—the last phase of the affair is reported to be that Mr. Scott, who has been appointed to carry out the work, is to erect an Italian building on his Gothic plan. And yet it is still doubtful if we shall ever see how successfully he can cope with the difficulty: in fact, the several abettors of the rival styles seem determined to fight it out to the death; and the admirers of English architecture claim for it such an unlimited power of adaptability to all places and all circumstances, that it may be after all that we shall get a Classic building with a Gothic interior. Much has been said about a certain deputation which waited on the Premier to express their opinion on the style that should be adopted,—the one side stigmatising it as an unprofessional and unfriendly proceeding; the other deprecating any inference of a personal nature, and protesting that everything was done in praiseworthy anxiety for the public benefit. It strikes me however that the object of the deputation, to be good for anything, ought to have been entirely of a personal character. Granting Classic to be the most appropriate for the purpose, as contended for by the deputation, surely the nation has a right to request that the work be carried out by the most skilful man in that particular branch, and not by one whose known predilections, and for the most part his practice, lie in an entirely opposite direction. We all cheerfully subscribe to Mr. Scott's general capabilities, but the process seems to be somewhat analogous to that of a man going to an eminent homœopathic physician, and insisting on being treated for his disease allopathically—he may get cured no doubt, and his friend while protesting against his responsibility may be glad to take his fee; but one would think it had been much more satisfactory to have applied at once to a physician who had made that course his particular study. And therefore while my own predilection is decidedly in favour of the Gothic view of the question, and I desire to give the deputation all the credit for not wishing to deprive Mr. Scott of the job, I think they would have done the state more service and acquired greater credit for themselves if (after handing in a presentation copy of Weale's 'Rudimentary Treatise on Architecture') they had advanced their own opinions as to the particular style, and suggested that either by competition or in some other mode the best man for the purpose should be selected and called in; at the same time expressing their conviction that if Mr. Scott were retained he should be allowed to carry out what he considered to be best adapted for the requirements; so that while the whole responsibility of any failure or dissatisfaction hereafter would rest with him alone, he might, if fairly entitled to it, secure for himself all the honour of a successful issue.

One occurrence has taken place since we last met, which has shed a gloom on our undertakings, more especially as regards the metropolis,—I mean the unfortunate disagreement between the masters and men in the building trade. I scarcely think this is the proper place for discussing the respective merits (or rather I should say the *demerits*) of the strike and the lock-out, as the question has in so many places been thoroughly sifted; but I should hardly be right in neglecting the opportunity for a passing allusion to a subject which, in its effects on labour and capital and increased cost of building, is calculated so nearly to affect ourselves in a professional point of view.

We are none of us bricklayers or labourers, and many of us are annoyed because important works are delayed, and in a great measure our interests as well as our feelings and prejudices are enlisted on the side of capital; and it is therefore, perhaps, difficult for us to look on with an impartial eye; still we cannot but think, when we hear so much on the one side of the rights of labour and the duty of capital, that great as are the responsibility of capital and its liability to abuse, its privileges and rights must be somewhat in proportion, and that its possessors are perfectly justified in taking measures for its protection against the effects of tyranny and extortion, from whatever quarter they may come.

One of the early manifestoes issued by the conference, alluding to workmen, says, 'the disposal of their own industry is a sacred and indisputable right—this right they have exercised, and they have done no more. The men have said to their employers, we conscientiously consider our time and labour worth 5*s.* 6*d.* per working day of nine hours, this would leave you a fair profit, and we will not sell it to you at the rate of ten hours for 5*s.* 6*d.*' The masters having refused to purchase the mens' time and labour on these terms, the latter have declined to sell any more of their labour and time at the rate of 5*s.* 6*d.* per ten hours (this by the way seems virtually to abandon the principle of the nine hours movement, and make the strike a mere question of wage); but the manifesto goes on, 'the men have also, as they have a legal right to do, advised their fellow-workmen to take the same course.....For refusing to sell their labour at less than they believe it is worth—for exercising a right more sacred and indisputable in our country and in our time than in any other—they have been overwhelmed with abuse and charged with conspiracy.' 'This,' says Mr. Potter (by *order* of the conference), 'is the workman's case, the simple and unvarnished truth.' It may be so—but is it the whole truth, and nothing but the truth—and would it not have been better for the workmen and more candid

Digitized by Google

to the public if, in manipulating their case, the conference had given a little varnish to the truth; then perhaps would have appeared on the surface those finer lines and markings which are of no less importance in rightly estimating the value and beauty of the material than those of a coarser nature which first catch the unpractised eye in looking on it in the unvarnished simplicity of its natural state. For, passing by the fallacious principle shadowed forth, that the wages of the workmen should be regulated by the profits of the capitalist—leaving the workmen in many instances, I fear, but poorly off—let us consider for a moment the advice supposed to have been given by those workmen who had struck to their fellows, and assuming many believed the wages were too low and the hours too long, and were desirous also of taking the same course of ceasing to work for those wages; what was the meaning of a notice issued to the effect that the workmen of any firm striking without permission would not be entitled to the allowance?—by *order* of the conference. Thus compelling men to work for wages they considered too low, and obliging them to contribute from this already inadequate source for the maintenance of those who might as well be at work as they.

Again, the way it was attempted to attack the masters in detail, and thus compel them indirectly to contribute to their own discomfiture, however legal the right may be, surely it is neither sacred nor indisputable: it is certainly tyrannical and un-English; and we cannot wonder at the masters having combined in the attempt to strike at the root of the whole system.

It would be well if the relations of masters and workmen could be clearly defined on a broad and liberal basis, but it is just these very so-called indisputable rights we hear so much about that are the real cause of the dispute.

Suppose a doctor in the exercise of his indisputable right refuses to attend a patient without payment of a large fee, and the patient in the exercise of the same privilege refuses to employ him. The patient dies—the country, perhaps, suffers an irreparable loss, or a family is deprived of its chief mainstay. Surely someone must be to blame—but have not each had their right? May we not find a solution to the question in the fact, that each sacred and indisputable *right* is invariably accompanied by a corresponding *duty*, equally sacred and indisputable, from which it is inseparable and without which it cannot exist at all. And is not this the case of the builders and their workmen, one which in its very nature and circumstances cannot be adjusted on the bare rights of the respective parties, without some compromise or mutual confidence. We all know how difficult it is clearly to mark out our line of duty and strictly adhere to it, and the danger of being led away from the right, and the almost inevitable certainty of there being wrong on both sides. Each party has tried its strength sufficiently to make it obvious that its rights cannot with impunity be encroached upon; and I hope the time has now arrived when by the withdrawal of the declaration on the part of the masters, and the expurgation by the societies of all those offensive and vicious bye-laws which interfere with the workman in the free and unfettered disposal of his own industry, we may see operations renewed, and a happier tone of feeling called into existence. There ought doubtless to be a greater reciprocity of confidence between masters and men, and I for one should consider it a calamity greatly to be deplored, if either party were obliged to succumb to the superior obstinacy or power of endurance of the other.

And now, turning from matters of a more public interest, I should like to say a word or two about ourselves. We have been congratulating each other and everybody else, almost, I dare say, *ad nauseam*, on the prospect of our coming to this building, and on our having come at last; and have repeated the history of how we got here so often; that I think it is unnecessary to say any more on the subject, and I will take it for granted we have done the best thing we could; but on the opening of this the first session in the new building, it would seem proper for me to state what are my own impressions of the aim and object of our association, both for the sake of recalling them to the mind of our own members, and of giving some reason to those who have not yet joined us why we appear before the public at all.

It will doubtless be generally conceded that there should be some body, perhaps a corporate one of an influential character, and comprised of men of standing and experience, who could represent officially the profession at large, and who would be in a position to take such steps as might be thought desirable for the interests of the general body; and to my own mind, the Institute of British Architects seems to be the only one in the position among ourselves capable of so acting: its efficiency and the value of its representative element might no doubt be considerably increased, but I wish to avoid any discussion on what goes forward in "another place," and I only mention the subject in order to correct an impression which occasionally gets abroad that the Architectural Association is a society of young men aspiring to guide the profession by a policy in direct antagonism to the Institute. Nothing can be more erroneous than this supposition. Those who are acquainted with us know that our intention and object is to afford certain facilities for study to the younger members, and to be the means of communication between the profession and all those interested in architecture and its kindred pursuits, and that our present constitution is based on the most free and liberal principles: we have no "bones," and no tickets of admission are requisite to our discussions, which are open to everybody. Our members, who comprise several Fellows and Associates of the Institute, besides independent members of the profession, students and amateurs, have equal rights, and each one without distinction is allowed not only to take part in discussions at the ordinary meetings, to vote for officers and on the general business of the society, but also is eligible to become a member of the managing committee; and therefore any idea that we are in a position to set up ourselves to dictate to the profession at large is founded on fallacious premises. What we claim for our association, and what to a great extent we believe has been carried out, is, that by its class of design, the papers which are read at the meetings, and by other means, it affords greater facilities for self-education and the acquisition of information to its members than are to be met with elsewhere; that it is the collector and exponent of the views and opinions principally of the younger members of the profession, and of those among the public who take an interest in the progress and welfare of our art; that the committee do their best to bring into notice these opinions, and as far as they can give them practical effect. Some of our experiments have met with signal success, while other principles enunciated have, we must confess, signally failed in practice;—some, may be, because they were radically wrong in theory, others perhaps because the time has not yet arrived for them to be appreciated; but we are not discouraged in this, we look upon our failures as being almost as useful in their way as our successes. We have a continual accession of new and younger members; and we are sure if there is anything good in our theories they will be soon revived, and with improved applications of them will ultimately be brought to bear for the general benefit. The foundation of our association itself was the result of a series of experiments,—various forms of constitution were tried, until at length the one was decided on which has now for years in principle remained intact. We all of course need reform, and I hope that from time to time as necessity or occasion require, modifications will be introduced to extend our usefulness as far as possible; but I do trust that our main distinguishing feature—that of treating all our members on an equality—will never be interfered with, for I believe that a society founded on similar principles to our own is a natural consequence of the present state of public opinion and education; and though like all other societies we have had our periodical depressions and elevations, I think I now see before us a useful future. And I would most strongly urge on our younger friends of the profession the advantages of such a society as we claim to be, for besides affording them opportunities for study in our class of design, and the expression of their own opinions on all subjects, the more we increase the number of members the better shall we be able to express the views of the whole body, and the greater will be the chance of seeing them carried out in a practical manner."

Restoration of Lutton Church, Lincolnshire.—Extensive alterations are now going on at the church of this village, (a hamlet in the parish of Long Sutton). The parish commenced to restore and reseat the nave and aisles without the aid of an architect, but for the works required to the chancel professional advice has been secured. Entirely new windows have been inserted at the east end and north and south aisles; a new roof has been put on, and a vestry built on the north side. The new fittings of the chancel will be of wainscot oak, and Minton's tiles will be used for the paving. The architect employed is Mr. William Smith, New Adelphi-chambers. In the nave the seats will be of deal of a plain character. New windows of a suitable design replace the wretched round-headed windows formerly in the south aisle, and a new south porch has been built.

Digitized by Google

INSTITUTION OF CIVIL ENGINEERS.

Nov. 8.—*First Meeting of the Session* 1859-60.

JOSEPH LOCKE, Esq., M. P., President, in the chair.

PREVIOUS to commencing the proceedings, Mr. Locke, M.P., president, rose and said:—

I cannot permit the occasion of opening a new session to pass without alluding to the irreparable loss which the Institution has sustained by the death, during the recess, of its two most honoured and distinguished members.

In the midst of difficulties of no ordinary kind, with an ardour rarely equalled, and an application both of body and mind almost beyond the limit of physical endurance; in the full pursuit of a great and cherished idea, BRUNEL was suddenly struck down, before he had accomplished the task which his daring genius had set before him.

Following in the footsteps of his distinguished parent, Sir Isambard Brunel, his early career, even from its commencement, was remarkable for originality in the conception of the works confided to him. As his experience increased, his confidence in his own powers augmented; and the Great Western Railway, with its broad gauge line, colossal engines, large carriages, and bold designs of every description, was carried onward, and ultimately embraced a wide district of the country. The same feeling induced, in steam navigation, the successive construction of the Great Western steamer, the largest vessel of the time, until superseded by the Great Britain, which was in its turn eclipsed by the Great Eastern, the most gigantic experiment of the age.

The Great Ship was Brunel's peculiar child: he applied himself to it in a manner which could not fail to command respect; and if he did not live to see its final and successful completion, he saw enough in his later hours to sustain him in the belief that his idea would ultimately become a triumphant reality.

The shock which the loss of Brunel created was yet felt, when we were startled by an announcement that another of our esteemed members had been summoned from us.

Of that friend I feel it to be a difficult task to speak without giving way to feelings better fitted for the closet than a public assembly. ROBERT STEPHENSON was the friend of my youth, the companion of my ripening years, a competitor in the race of life; and was as generous as a competitor as he was firm and faithful as a friend. This will, I know, find an echo in the hearts of all around me; and your feelings will supply that laudation in which it would seem inappropriate for me to indulge.

Like Brunel, Robert Stephenson commenced his professional career under his father, George Stephenson. His early years were devoted to the improvement and construction of the Locomotive, and to him we owe the type of those machines, many of which are now actually in use on our railways.

From the time of the Liverpool and Manchester Railway—when our joint report contributed in a great degree to the adoption of the locomotive engine as the means of transport—and of the subsequent London and Birmingham line, with its long parliamentary contests, its Kilsby Tunnel, and other difficulties inherent in so new an undertaking, a multitude of other lines followed, in which there had to be foreseen and provided for numerous difficulties, all of which were met and surmounted with coolness and consummate skill.

Among these great works may be mentioned the Royal Border and High Level Bridges, and more especially the Conway and Britannia Bridges, which were the first examples, on so vast a scale, of the tubular principle, and the Bridges across the St. Lawrence and the Nile, remarkable alike for their grandeur of conception and successful execution.

To my present hearers the enumeration of the works in which Robert Stephenson was engaged would be as a "twice-told tale;" but we must look back with interest upon the days of the "Battle of the Gauges,"—the discussions upon the Atmospheric System,—and the numerous topics which have been argued within these walls and elsewhere.

In the enjoyment of a distinguished name and reputation, Robert Stephenson, like Brunel, has been cut off while still in the middle period of life; and although he pursued his profession with persevering energy, and accomplished in it those triumphs of the successful application of a mind well trained and stored with practical and theoretical knowledge of various kinds, and achieved some of the greatest works of art which have been witnessed in our day, he at the same time obtained an eminence in the scientific world rarely reached by any practical professional man.

It is not my intention at this time to give even an outline of the works achieved by our two departed friends. Their lives and labours, however, are before us, and it will be our own fault if we fail to draw from them useful lessons for our own guidance. Man is not perfect, and it is not to be expected that he should be always successful;—and, as in the midst of success we sometimes learn great truths before unknown to us, so also we often discover in failure the causes which frustrate our best directed efforts. Our two friends may probably form no exception to the general rule; but judging by the position they had each secured, and by the universal respect and sympathy which the public has manifested for their loss, and remembering the brilliant ingenuity of argument, as well as the more homely appeals to their own long experience often heard in this hall, we are well assured that they have not laboured in vain. We, at least, who are benefitted by their successes, who feel that our Institution has reason to be proud of its association with such names as BRUNEL and STEPHENSON, have a duty to perform, and that duty is to honour their memory and emulate their example.

I ought to add in conclusion, that amongst the many private and public bequests made by Robert Stephenson, is one to this Institution of the munificent sum of two thousand pounds.

The paper read was "*On the Process of Raising and on Hanging the Bells, in the Clock Tower at the New Palace, Westminster.*" By Mr. JABEZ JAMES, A. Inst. C.E.

It was stated that the first large bell, which weighed upwards of 15 tons 18 cwt., and was cast by Messrs. Warner and Co., at Norton, near Stockton-on-Tees, was fractured while suspended from a staging at the base of the tower, during the course of experiments on the tone of the bell. The fracture took place on the opposite side from where the bell was struck by the clapper, which weighed 12 cwt. It passed from the lip through the sound-bow, and extended up the waist of the bell, and was about 40 inches in length from the lip. The fracture seemed to be clean, and the metal had a coarse dull appearance, and was full of minute holes, which were noticed in other parts of the bell when it was afterwards broken up.

The four quarter bells were also cast by Messrs. Warner, but the third having been condemned as defective had to be recast. The first, weighing rather more than 1 ton 1 cwt., was lifted in three hours; the second, weighing upwards of 1 ton 5 cwt., occupied three hours and a half; and the third, which weighed above 1 ton 13¼ cwt., took four hours. These three bells were raised by means of a single chain, made of bars ⅝-inch diameter, and a crab with a double purchase. The fourth quarter bell, weighing more than 3 tons 17¼ cwt., was lifted in six hours, by a similar chain reeved through a single pulley, and by a double-purchase crab. These bells were hung at the four angles of the tower, around the large bell, for the convenience of sounding, &c.

The second large bell weighed upwards of 13½ tons, and was cast by Messrs. Mears, at Whitechapel. The best method for raising this bell in a safe and economical manner having been carefully considered, it was decided to use a treble-purchase crab, with large blocks and a fall. A new chain, made by Messrs. Hawkes, Crawshay, and Co., 1500 feet in length, and tested to a strain of 10 tons, was employed. This chain, when reeved through two three-sheave blocks, and with a standing chain, gave a power equal to about 70 tons. As the bell was 9 feet in diameter at the sound bow, and 7 ft. 10½ in. in height, and the dimensions of the tower were only 8 ft. 6 in. by 11 ft. 1 in., it was not possible to lift it by the crown, with the mouth downwards. Consequently a cradle had to be constructed in which the bell should rest on its side. Friction rollers were attached to the cradle at the top and at the bottom, which served as guides, and rubbed against balks of timber set upright in the shaft. The upper block was made fast by a shackle and clip to a flitch beam formed of two plates of iron fixed between six timbers; and the lower block was firmly secured to the cradle by massive bolts and straps. The treble-purchase crab was fixed to a strong staging in the cast-iron lantern at the top of the tower, in such a position as to leave a distance of about 19 feet between the bottom of the crab and the crown of the bell, when the latter was raised to its proper position. As the single barrel of the crab could not take up all the chain without incurring the risk of surging, consequent upon the coiling of the chain in so many thicknesses, several lifts were made, as stated in a tabular statement given in an appendix, in which was also recorded the time occupied for each lift, and the fleeting of the chain. An iron chain-stopper of special construction was made, for the purpose of holding the chain during the fleeting on the drum of the crab. The weight of the bell and the cradle and ironwork, together with the chain, blocks, &c., was about 25 tons, exclusive of friction. The process of raising commenced at six o'clock in the morning, and continued without intermission until noon on the following day, when the bell was safely landed on a staging in the clock room. The cradle was then disconnected, and the bell was turned over with the crown upwards. An eye-bolt was passed through, and being now clear of the shaft, the bell was lifted in the usual way from the clock room to the bell chamber.

Digitized by Google

The total height the bell was raised was 201 ft. 3½ in., at an average velocity of about 6 ft. 5 in. per hour.

The paper then proceeded to state the experiments that had been made before the weight of the hammer and the distance it should fall through were finally settled. The weight was decided to be 6 cwt. 3 qr. 10 lb., with a fall of 13 inches. This arrangement for striking the hours was continued until the bell was discovered to be fractured in two places. One of the cracks was precisely in the same position in this bell as in the former one, exactly opposite to the place where it was struck by the hammer, and the other was about 2 feet away from it. The first fracture appeared to be about 15 inches and the second about 24 inches long; but they did not extend through the thickness of the metal, nor within 2 or 3 inches of the lip at present.

The whole of the works for raising the bell were carried out by Mr. Hart, assistant to Mr. James, under the superintendence of Mr. Quarm, clerk of the works at the New Palace.

In the discussion, it was remarked, that the composition of the metal of the bell was not the same as that usually adopted in this country and on the continent, there being a greater proportion of tin than was customary. It was also thought, that the use of charcoal-smelted copper, as was the case in Russia, was advantageous. It was suggested, whether the interval between the blows of the hammer might not have been too short, and whether the chattering of the hammer, due to its not being cleared immediately after striking, might not have a tendency to produce numbness, and hence stun the bell, and contribute to its fracture. It was urged that the great weight and fall given to the hammer must have acted prejudicially. These were supposed to be rendered necessary by the thickness of the metal, which had been made considerable, in order to guard against accident; but it was contended that it had a contrary tendency.

GEORGE P. BIDDER, Esq., Vice-President, in the chair.

Nov. 15.—The paper read was "*On the Origin, Progress, and Present State of the Government Water Works, Trafalgar Square;—with a few facts relating to other Wells which have been sunk or bored into the Chalk Formation.*" By C. E. AMOS, M. Inst. C.E.

The author commenced by stating, that a good supply of water having been required for the fountains in Trafalgar-square, it was determined, in the year 1843, to carry out a plan which had been suggested by Mr. James Easton. This was so framed as to include the water supply for the public offices. The water was to be obtained and raised by engine power from the springs beneath the London clay. The quantity of water required for condensing the steam of the engine being too great to be taken from the main spring in full quantity, it was considered expedient to use cooling ponds; and it was thought that a small quantity of water in excess of that required for the public offices, running continually into the cooling ponds, would keep the water clean, and in a state fit for the purpose of condensation. The basins of the fountains were intended to form the cooling ponds. The water from them was to be taken for the use of the condenser, afterwards to be raised into a cistern, from whence it was to be conveyed to and be passed through the jets of the fountains, where, meeting with the resistance of the air, it would be partially cooled, and returned to the basin for further circulation.

Estimates having been made, it was found that the yearly interest on the cost of erection, added to the cost of working, would be less than the sums hitherto paid annually for the water supply to the public offices, and that consequently the playing of the fountains could be effected without cost to the government. A contract was then made with Messrs. Easton and Amos for the execution of the works; and a piece of ground having been selected in Orange-street, the works were commenced in January 1844, by sinking the first well to the depth of 174 feet. A cast-iron pipe 15 inches diameter was then driven through 30 feet of plastic clay and 10 feet into a stratum of gravel, sand and stones, being left standing several feet up in the well. Within this another pipe of 7 inches diameter was driven through 35 feet of green coloured sand, and 3 feet into the chalk formation, and the boring was then continued to the total depth of 300 feet from the surface. A considerable quantity of water came from the sand, but a much larger supply was obtained from the chalk. A second well was sunk in the inclosure immediately in front of the National Gallery, to a depth of 168 feet from the surface. A pipe 14 inches diameter was then driven through the plastic clay, and into the gravel, sand, and stones beneath it. Within this a pipe 7 inches diameter was driven through 42 feet of green coloured sand, and 3 feet into the chalk, the boring being continued to the total depth of 383 feet. The springs were found to be stronger than those in the well in Orange-street. A tunnel 6 feet diameter and about 400 feet long was driven to connect the two wells; the bottom of it being about 123 feet below T.H.W.M. A catch well 5 ft. 6 in. diameter and 32 feet deep was sunk just outside the engine house. A tunnel was driven from it, passing beneath Castle-street and the National Gallery, to contain the pipes for bringing the water back from the basins of the fountains to the catch well.

The paper then proceeded to describe the situation of the different tanks or reservoirs in the water-tower, and their purpose; and next gave a brief account of the high-pressure condensing steam engine, on the Cornish principle, for working two sets of pumps, one being capable of raising 100 gallons of water per minute from the springs to the tank, and the other 550 gallons per minute from the catch well into the tank, for condensation and for the supply of the fountains. An auxiliary high-pressure, single-acting steam engine was also provided, to be used when the principal machine needed repair.

The works were finished in December 1844. Their total cost as completed amounted to nearly £8400. The water rose to within 90 feet of the surface (about 48 feet below T.H.W.M.) and was found to be of good quality. When the engine was pumping 110 gallons of water per minute, it could only lower the water 4 feet in the well.

In 1846 a further demand for water having been made, a larger pump was substituted, which was capable of raising 350 gallons of water per minute from the springs.

In 1849 a second well was sunk in Orange-street, and an engine of 60 H.P. on Woolf's principle, was erected. The well was carried to a depth of 176 feet, and a tunnel was driven to connect it with the other wells. A bore pipe was driven through the plastic clay, within which it was intended to drive a smaller pipe through the sand into the chalk and then to continue the boring as in the other wells. But an accident having occurred in driving the large pipe, which allowed sand to come up the bore hole, and made the water foul, the hole was stopped with bags of clay, and no further use had been made of it, than as a sump well to contain the pumps. The accident was accounted for in this way:—In driving the pipe great resistance was offered by the "hugging" of the plastic clay, and considerable percussive force had to be used. In consequence several of the screws which held the joints were shaken out, and the pipe having been improperly driven through the layer of gravel, sand, and stones, into the sand beneath, there was an escape of water through the screw holes, and sand followed in sufficient quantity to cause inconvenience.

The steam engine worked one double-acting pump for supplying the fountains, and two other pumps for raising water from the springs into the tanks above the building. At an average speed of sixteen strokes per minute, the first could throw 660 gallons, and the other two together 600 gallons per minute. This engine is the one now mainly used. The supply of water from the springs was still found to be abundant. The pumping of six hundred gallons per minute lowered the water from 20 feet to 24 feet, when it remained stationary as long as the engine was kept working. The level of the water did not appear to be gradually lowering, and it was stated that on December 1st, 1858, it rose to within 66 feet of T.H.W.M., being about the same level as it stood in December 1847. The author thought there could be no doubt that the greater portion of the water was obtained from the chalk.

He then referred to the fact of the towns of Brighton, Croydon, Deal, Epsom, Ramsgate, and Woolwich, being all supplied with water from the chalk formation. There was an uncertainty however of obtaining a good supply from the chalk, as was illustrated in the case of the well sunk at Messrs. Truman's brewery. In 1857 a greater supply of water being required by the Messrs. Truman, it was determined to extend the works. In the first place the sand and water above the chalk were shut out, then the well was continued to a depth of 300 feet from the top, when it was discontinued, as no water came up the well hole. As the chalk showed indications of water at the depth of 285 feet, the floor of the tunnels was commenced at that level. These tunnels were 5 ft. 6 in. high by 4 feet wide; that on the north side was driven to a length of 57 feet, and that on the south side to 48 feet. The quantity of water now obtained did not exceed 12½ gallons per minute. The water of the springs in the sand had been taken by tapping the cylinders at the bottom, instead of as hitherto near the top of the sand stratum.

A well sunk at Messrs. Coombe's brewery, to a depth of about 48 feet into the chalk, produced a supply of 70 gallons per minute. The water stood 20 feet higher in this well than in the Trafalgar-square well, while the water in both wells was in a state of rest.

SUBMERGENCE OF TELEGRAPH CABLES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—In your report of my remarks in the discussion which followed the reading of Mr. Cox's paper on the submergence of telegraph cables, at the recent meeting of the British Association in Aberdeen, there are one or two passages presenting inaccuracies which have obviously arisen from the difficulties under which the reporter was placed as regards hearing distinctly. There are only two of these which are of sufficient importance to require any notice; on them you will oblige me by inserting the following corrections.

1. After the sentence, "Then the cable was in a state which appeared to be very dangerous," which may have been the words I used, occurs the following:—"It hung nearly vertical from the stern of the ship, and it became soon thereafter a certainty that the shore end of the cable was loose." This is entirely different from anything I said, as I trust your readers will generally have judged. What I said was really to this effect:—That for a time

Digitized by Google

the cable with every pitch of the ship was to be seen alternately hanging loose—nearly vertical over the stern, presenting the appearance of having been broken short, and then immediately drawn up so as to look like a rigid bar, or sometimes even flying above the straight line so as to present a convexity upwards.

2. A little further on in the report occurs the following:—"I am aware that many practical men supposed it impossible that the cable could untwist in coming out of the ship, because, as was alleged, both ends are fixed, and therefore of course continued untwisting cannot take place. But this objection to the result which I anticipated, overlooked the twisting up again which must take place in the lower part: and I believe it would make the very hair of some of those who so objected stand on end, to see the cable at the 2 mile depth." The last clause of this sentence is intended no doubt to represent something which I said with reference to quite a different subject from that in connexion with which it is reported. In place of the words "those who so objected," the correct report would have been "those who objected to a kink as fatal to a submarine cable." The fact having been that many had written and spoken as if a kink under water was enough to destroy the efficiency of a submerged cable, while in my opinion no amount of twisting up into kinks which a submarine cable of any of the forms hitherto ordinarily adopted can acquire by the elasticity of its own sheath, can possibly do the slightest damage to a sound gutta-percha core and copper wire within. The actual expression referred to was used after I had pointed out that in all probability there must be a very decided kink every few yards along the Atlantic cable where it lies in deep water, or of any other cable paid out with a good deal of slack and laid in a deep sea. WILLIAM THOMSON.

College, Glasgow, 23rd Nov. 1859.

REVIEWS.

On the Construction of Wrought-iron Bridges. By JOHN H. LATHAM, M.A., C.E. With plates and woodcuts.—Macmillan and Co., Cambridge, 1858. 8vo.

(SECOND NOTICE.)

A practical man generally avoids reading theoretical books. He knows, on the one hand, that they are liable to be long or intricate, or both; and he is also equally certain that it is useless to take the subject up cursorily—that to dabble in theory is as unremunerative as to dabble in practice. Indeed nothing is more wasteful and misleading than to *dip* into the theory of a subject, without mastering carefully all its peculiar details.

The book to whose pages we are now returning possesses certainly one advantage, that it is concise and well packed. The practical subjects treated of in it are also kept distinct, so that the whole book has not to be read in order to understand each branch of the subject; and it may be safely said, that no practical man can read its pages without gathering much matter for reflection, some pointed suggestions as to manufacture, and though it may surprise him, valuable information of the most practical kind.

Mr. Rendel, who, since the deaths of Mr. Brunel and Mr. Stephenson, is at the head of his profession as far as regards the magnitude of the iron bridges which he is constructing, is engaged in bridging over some of the largest tributaries to the Ganges, for the East Indian Railway, by wrought-iron bridges. Not to digress here into any statement of the time saved by this method in getting that line open, we will give a brief sketch of (what is too little known) the extent to which iron bridges are being used in India. The iron lattice girders for the Soane are already in process of erection on that river. This tributary of the Ganges is in summer a broad quicksand 80 feet deep, with the winding branches into which the river divides itself at that time occupying uncertain positions in its bed: in winter the whole becomes a sweeping sheet of water, rarely under a mile and a half in width. For this river 28 spans of lattice girders, each span 150 feet in the clear, are now in course of erection on the spot, to form a bridge 1 mile 500 feet long. Besides this, the Keeul and Hullohur and Tonse are smaller streams for which similar spans have been sent out: their united length is three-quarters of a mile. But the foundations for the bridge over the river Jumna alluded to in the September number of this Journal, are for a still more gigantic bridge, though its total length is less than that for the river Soane. It will have 14 piers, each within a few inches of 220 feet distant from its neighbours, which when connected by its iron girders, now in course of construction by Messrs. Peto and Betts, will form a bridge of 3300 feet in length consisting of 15 spans, each 200 feet in the clear. These magnificent bridges carry besides the railway a bridle roadway for foot passengers, horsemen, and travellers by *dawk*.

It will be seen that these bridges are constructed in England, thence to be sent out in pieces on board ordinary ships, then to be easily transmitted up the country, and finally put together almost entirely by *native* labour. Mr. Latham has contributed valuable suggestions in aid of this object, the circumstances connected with which have created a demand for engineering skill, arrangement, and accuracy of no ordinary kind.

In no other country than India could such a field for engineering labour at present be found; and the required *adaptability*, *economy*, and *magnitude* of design, perhaps few engineers but Mr. Rendel could supply. It is an observable characteristic of the bridges thus being constructed under this engineer, that elegance of design is secured. Indian taste is more imperative in demanding this accessory to works of public utility than the public taste of England or her colonies; and we are quite sure that the moral effect of appropriate neatness and ornament will fully repay the small expense occasioned by it.

The following is a general outline of the contents of the book before us:—The first chapter contains a sketch of the forms and names of bars, plates, angle-irons, &c., with the sizes of each, for which current prices are quoted. The method of workmanship in setting up and rivetting is described, and the efficiency of iron in each of its forms defined; and the author fixes the amount at which he intends to estimate it in his calculations.

The next chapter investigates the strength and advantages of joints of different kinds. Some of the examples are original, and the whole worthy of the attention and criticism of practical men. This apparently simple subject forms the foundation upon which all calculations depend for their value. If the strength of joints be not known and definite, then the value of calculation is proportionably doubtful, for then its precise results cannot be acted upon with corresponding precision.

Next follow the calculations of the strains upon different forms of girder, upon which we have commented in our former notice of this work (*ante* p. 65). The practical student is wisely recommended by the author to omit a piece of algebraic analysis in the third chapter. He will thus escape some vexatious errors which should never have been overlooked in the preparation of the work for the press. Hitherto the mathematics of the subject (with the exception of the above-mentioned analysis) accommodate themselves to the plainest arithmetical processes.

The author has wisely prefaced his analysis upon the subject of deflection by a practical example, showing how near an approximation his method has enabled him to make to the results of actual measurement. A lattice bridge of 150 feet span, the weight of which was 130 tons, was loaded with 350 tons as a test: the deflection of its centre below the position that it occupied when under the weight of the bridge alone, was 2·9 inches. On removing the test-weight the centre point returned to ·8 inches. The deflection due to that weight by calculation was 2·15 inches, that is supposing iron to extend (or compress, as the case may be) ·84 ten-thousandths of its length per ton strain on each square inch. He makes a suppositious division of the deflection of this bridge to suit his calculation, as follows:—

Permanent set due to workmanship	·75	inch
,, ,, iron itself	·05	,,
Deflection to be expected on every repetition of the test	2·10	,,
	2·90	,,

and the probability of this division certainly confirms the truth of his calculation. He then deduces that such a girder should be built with 3 inches cambre.

Mr. Latham does not here tell us exactly by what means he arrived at this satisfactory result; but from his subsequent analysis we are able to gather his method of calculation: throughout, deflection is considered solely as the result of the extension or contraction of the various parts of the structure due to the weight impressed. By his method, the horizontal members and the connecting web or lattice are treated independently, and expressions are found successively,—first for the deflection due to the yielding of the web under its vertical strains, second for that due to the change in the length of the top and bottom horizontal members of the girder; in which the resistance of the web, if of plate, to curvature is taken into account by the expedient of supposing one-sixth of its bulk to be added to the top and bottom.

The most apparent practical questions for engineers with regard to deflection are undoubtedly what amount of cambre ought to be given to a bridge; and by what means that cambre can be best obtained. These are the subjects for inquiry put by Mr. Latham at the beginning of his investigations. The first is answered by his investigations, only so far as depends on the change of form which must be anticipated in a bridge owing to the stretching of the iron of which it is built. For any tightening up of joints, or, as he names it, for any anticipated set due to workmanship, special allowance will have still to be made.

We will not enter into an investigation of the deflection of a bridge under a rapidly passing load. We are glad to see this subject touched upon; for it is probable that no inconsiderable shocks are caused, not only by the sudden dropping, as it were, of the engine into the hollow caused by the deflection of the bridge under its weight, but also by the centrifugal force of the engine and carriages as they run over that hollow. This last Mr. Latham does not consider, and this we think a defect, since it can be proved to cause a perceptible, though not in itself important, addition to the load. In the accurate experiments made by Prof. Willis,

Digitized by Google

that talented observer found that a considerable shock was also caused by the passage of the engine from one straight rail to another, when the bridge was curved by deflection. All these sources of violence tend to warn the engineer against making wrought-iron bridges too slight, both on account of the absolute weakness on the one hand, and of the increase of their deflection and consequent exposure to violent shocks from rapid trains on the other. Mr. Latham recommends that a lower standard of efficiency should be adopted for iron in spans under 40 feet; or, in other words, that such spans should be made 10 per cent. stronger than larger ones.

We now turn to the discussion of the merits of the various forms of bridges represented in the figures. This discussion Mr. Latham carries out in a form readily intelligible to scientific men who are willing to take for granted the results of previous investigations.

The whole question here involved may be shortly stated thus:—If a suspension bridge and girder of equal spans and depths are calculated to carry equal loads, then the necessary weight of the latter is found to be three times as great as that of the former (in the particular example taken, viz. of 400 feet span); can we, by any other form of bridge, without losing the lightness of the suspension principle, obtain sufficient stiffness to adapt it for railway traffic? Engravings of various forms designed from time to time with the view of effecting this object are given in the work. We shall give a very short sketch of the merits of each, as set forth by Mr. Latham.

He first points out the deficiencies of the suspension bridge, which he arranges under four heads. In the first place, the load is in that kind of bridge supported by means of those rods only which attach the *loaded* part of the roadway to the chain: hence a load entirely on one side of the centre draws the flexible chain down on that side; the deflection thus caused is so considerable that it has sometimes been measured in feet. Secondly, the sudden taking off or putting on of such a load causes an oscillation of equal amount with the deflection; the shock thus produced Mr. Latham shows to be more than one hundred times as great as that produced in a girder of like dimensions. Thirdly, the repetition of any cause tends to accumulate oscillation; the danger of marching soldiers in step over a suspension bridge is well known; the same danger attends the regular pulsations of the pistons and sidegear of a locomotive. Fourthly, change of temperature, which on a girder whose ends are free produces no effect beyond a change of length, will, by affecting the chains, cause the centre of the suspension bridge to rise and fall a considerable distance.

By a design shown, of which *Dredge's* patent is a development, a bridge is obtained but little heavier than the suspension bridge. Mr. Latham shows that the three first defects are modified by this plan, but that it is inapplicable to large spans. We may add that the suspension bridges in Regent's-park are constructed on Dredge's patent, and those who have walked over these will agree with Mr. Latham in considering them inapplicable, in any form, to locomotive traffic.

Ordish's bridge is a good deal heavier than the suspension bridge, but is yet much lighter than a girder. The fact of the roadway being supported independently at several points by straight chains, whose weight is in turn borne by a light suspension chain, obviates many defects in the former designs. It seems to us that Mr. Latham treats this bridge too much as a pure suspension bridge, whereas its inventor proposes to combine with it somewhat of the principle of the design next considered, by making the roadway a continuous girder. This bridge seems worthy of a trial for railway traffic; still, says our author, "we see an element of vibration and violence which trial only can prove to be compatible with security, even at moderate speeds."

A design is given showing an attempt to unite the suspension chain and girder. The plan followed is, to make the girder support the load only, and to make the chain strong enough to carry the girder. In this design, again, change of temperature is the chief difficulty; as the chain rises or falls, it takes more or less strain from the girder; and consequently, arrange the two as we will, it is found necessary to use a chain heavier even than would be required for carrying the whole load; while in addition to this we have a girder of no small weight.

Mr. Latham concludes by proposing a design which he calls the *hanging girder*. We must refer our readers to his book for a discussion of this method: for all those who have been lately paying attention to this much-mooted point his investigations will have a special interest. Suffice it to say that for 400 feet span, and the same weight of roadway and load, of a united weight of 1¼ tons per foot run, he shows that the necessary weight of such a bridge is about three-fifths that of a girder, half that of a suspended girder, and as much again as that of a simple suspension bridge: the defects also of the latter are in the main remedied.

An Inquiry into the Principles of Beauty in Grecian Architecture. By the EARL OF ABERDEEN;—forming Vol. XXX. of 'Weale's Rudimentary Treatises on Architecture.'—London: John Weale, 1860.

The work before us consists of the introduction to Wilkins' translation of Vitruvius, written for that work by the Earl of Aberdeen on its first appearance some years ago, and is now reproduced by Mr. Weale in his series of Rudimentary Treatises.

On the service rendered by the issue of works of this description at a price which shall bring them within the reach of all classes interested in the practice and appreciation of correct sentiment in architecture, there can be but little question; and it is not that because of late years a *furor* has arisen in favour of perhaps a more indigenous style, we should lose sight of the indisputable claims upon us which the architectural works of Greece and Rome possess. Mr. Weale is therefore deserving of thanks for reproducing a work which seeks to point out and establish the principles upon which those pleasurable effects are based which are all but universally admitted to be created by the examination of the best remains of the Grecian period.

The principles which originated the peculiarly fitting and expressive edifices of Greece and Rome, as well as those also of less classic ages, are the grand anchors which should be relied on and held by, for it is not by copying and applying a Grecian portico or a pediment, a Roman or Italian arcade, or a Gothic tower and pinnacles, irrespective of fitness to the purposes required and the place or country for which it may be designed, that either a Grecian, Roman, Gothic, or any other building, in the true sense of architectural propriety, is produced. This it is to be feared has been in many instances less thought of of late than should be; and this treatise will be well timed if the consideration of the groundwork of Grecian productions there inquired into should have the effect of qualifying only the taste for that less pure foreign expression, not always associated with usefulness, which is so prevalent at the present day. Why can we not have, like our forefathers, buildings constructed with reference to our climate, present wants, and habits?

The ancient Greek modified in adopting from the earlier architecture of Egypt, as did the Roman from that of Greece, each to the altered aspect of their own necessities and state of society, as we may doubtless do from that of either or of other lands, but, as the concluding observations of the treatise under review inculcates, with due regard to their "essential qualities of excellence, as they are founded on reason and are consistent with fitness and propriety." Each may be imitated, not however "with the timid hand of a copyist," or, it may be added, with a wild and unchecked notion of novelty, "but their beauties should be transferred to our soil, preserving at the same time a due regard to the changes of customs and manners, to the difference of our climate, and to the condition of modern society. In this case, it would not be so much the details of the edifice itself, however perfect, which ought to engross the attention of the artist, but he should strive rather to possess himself of the spirit and genius by which it was originally planned and directed; and to acquire those just principles of taste, which are capable of general application." A whole sermon on architectural art is contained in these words.

LITERARY AND PHILOSOPHICAL SOCIETY, MANCHESTER.

AT a meeting of the above society held on the 18th October, Dr. F. Crace Calvert presented in the name of Mr. Arnaudon (from Turin) a paper, and *Samples of Green Colours used in Painting and Printing*, and especially referred to two new chrome greens, one of which is a new compound, corresponding to the monohydrate of sesquioxyde of chrome $Cr^2 O^3 HO$.

The author commences in his work to point out the qualities which a good green ought to possess in order to be suitable for painting. Then he reviews in a few words the different greens which are found at present in the market, together with the nature and properties of the same. Beginning with the history of the works already published on this subject, he next gives the description of his process for preparing his monohydrate of sesquioxyde of chrome, and which consists in exposing the bichromate of potash mixed with phosphoric acid and any desoxydising agent (for example, ammonia) for some time to the action of heat. The soluble salts are then removed by washing.

The green so prepared has not only a beautiful shade, but like that of Mr. Guignet (made by decomposing the borate of oxyde of chrome by water) possesses the curious property of remaining green under the influence of artificial light.

The following extract of a letter received from Professor W. THOMSON, F.R.S., was read:

"I have a very simple 'domestic' apparatus by which I can observe atmospheric electricity in an easy way. It consists merely of an insulated can of water to set on a table or window sill *inside*, and discharge by a small pipe through a fine nozzle two or three feet from the wall. With only about ten inches head of water and a discharge so slow as to give no trouble in replenishing the can with water, the atmospheric effect is collected so quickly, that any difference of potentials between the insulated conductor and the air at the place where the stream from the nozzle breaks into drops is done away with in my apparatus at the rate of five per cent. per half-second, or even faster. Hence

Digitized by Google

a very moderate degree of insulation is sensibly as good as perfect, so far as observing the atmospheric effect is concerned. It is easy by my plan of drying the atmosphere round the insulating stems by means of pumice-stone moistened with sulphuric acid, to insure a degree of insulation in all weathers, by which not more than five per cent. per minute will be lost by it from the atmospheric apparatus at any time. A little attention to keep the outer part of the conductor clear of spider lines is necessary. The apparatus I employed at Invercloy stood on a table beside a window on the second floor, which was kept open about an inch to let the discharging tube project out without coming in contact with the frame. The nozzle was only about two feet and a half from the wall, and nearly on a level with the window sill. The divided ring electrometer stood on the table beside it, and acted in a very satisfactory way (as I had supplied it with a Leyden phial consisting of a common thin white glass shade, which insulated remarkably well, instead of the German glass jar—the second of the kind which I had tried, and which would not hold its charge for half a day.

I found from 13¼° to 14° of torsion required to bring the index to zero when urged aside by the electromotive force of ten zinc-copper water cells. The Leyden phial held so well that the sensibility of the electrometer measured in that way did not fall more than from 13½° to 13¼° in three days.

The atmospheric effect ranged from 30° to above 420° during the four days which I had to test it—that is to say, the electromotive force per foot of air measured horizontally from the side of the house was from nine to one hundred and twenty-six zinc-copper water cells. The weather was almost perfectly settled, either calm, or with slight east wind, and in general an easterly haze in the air. The electrometer twice within half an hour went above 420°, there being at the time a fresh temporary breeze from the east. What I had previously observed regarding the effect of east wind was amply confirmed. Invariably the electrometer showed very high positive in fine weather, before and during east wind. It generally rose very much shortly before a slight puff of wind from that quarter, and continued high till the breeze would begin to abate. I never once observed the electrometer going up unusually high during fair weather without east wind following immediately. One evening in August I did not perceive the east wind at all, when warned by the electrometer to expect it; but I took the precaution of bringing my boat up to a safe part of the beach, and immediately found by waves coming in that the east wind must be blowing a short distance out at sea, although it did not get so far as the shore.

I made a slight commencement of the *electro-geodesy* which I pointed out as desirable at the British Association, and in the course of two days, namely, October 3rd and 4th, got some very decided results. Macfarlane, and one of my former laboratory and Agamemnon assistants, Russel, came down to Arran for the purpose. Mr. Russel and I went up Goatfell on the 3rd inst. with the portable electrometer, and made observations, while Mr. Macfarlane remained at Invercloy, constantly observing and recording the indications of the house electrometer. On the 4th inst. the same process was continued to observe simultaneously at the house and at one or other of several stations on the way up Goatfell. I have not yet reduced all the observations, but I see enough to leave no doubt whatever but that cloudless masses of air at no great distance from the earth, certainly not more than a mile or two, influence the electrometer largely by electricity which they carry. This I conclude because I find no constancy in the relation between the simultaneous electrometric indications at the different stations. Between the house and the nearest station the relative variation was least. Between the house and a station about half way up Goatfell, at a distance estimated at two miles and a half in a right line, the number expressing the ratio varied from about 113 to 360 in the course of about three hours. On two different mornings the ratio of house to a station about sixty yards distant on the road beside the sea was 97 and 96 respectively. On the afternoon of the 4th inst., during a fresh temporary breeze of east wind, blowing up a little spray as far as the road station, most of which would fall short of the house, the ratio was 108 in favour of the house electrometer—both standing at the time very high—the house about 350°. I have no doubt but that this was owing to the negative electricity carried by the spray from the sea, which would diminish relatively the indications of the road electrometer."

NOTES OF THE MONTH.

Sea Walls and Breakwaters.—Messrs. Richardson and Jaffrey, of Hartlepool, have invented a new description of sea wall suitable for most purposes where protection is required for shipping, or the coast requires defence from the action of the wind and tide. It consists of a series of towers, which may be made of cast or wrought iron. These towers are connected by means of a lattice or screen composed of timber, or of cast-iron pipes or wrought-iron tubing. The space left between each tower is equal to the diameter of the towers. These towers when in position are filled up with masonry, or solid beton or concrete, or slag and concrete. A permanent gangway is fitted along the tops of the lines of towers. The plan the inventors propose in carrying out works on this principle is as follows:—The towers can be made and finished on shore, taken out to sea by means of a derrick, and placed in the positions which they are intended to occupy, being pumped dry to receive the solid matter with which they are to be filled. As they are placed in position, the permanent gangway is also carried across from tower to tower, serving instead of the temporary scaffold and gangway which the contractor would otherwise have to erect. The lattice or screen frames are also made on shore, and dropped in their places in grooves in the tower by means of the derrick. The screenwork, allowing the tides to flow freely in and out, prevents the silting up of the inner side of the harbour. Harbours may be constructed upon this principle at a great diminution of expense, contrasted with those constructed with solid stone walls; and even where it is desired to have a solid wall it will be found much cheaper to use iron towers filled in either of the ways above alluded to, and for the spaces between the towers to be filled with solid masonry. Works may be constructed on the principle of this invention in a very short time. The inventors propose in some cases to build the towers in stone, but generally iron ones are preferred.

Cast-iron Rifled Ordnance.—Recent experiments by the authorities at Woolwich have confirmed the opinion that cast ordnance when rifled are not capable of resisting the concussion attending the discharge, and that wrought-iron alone is applicable to the manufacture of rifled ordnance. The Royal Gun Factory at the Arsenal is, consequently, about to be re-modelled; the casting of guns of every description will cease, and Sir William Armstrong's method is to be introduced on an extensive scale. One of the experimental cast-iron ordnance rifled on Sir William's principle, on being tested, burst under the trial.

The Statue of Richard Cœur de Lion.—The statue of Richard I., the model of which was exhibited in 1851 in Hyde-park, and which became so familiar to visitors to the Great Exhibition held in that year, is about to be placed in Palace-yard, in the large open space opposite to the peers' entrance to the New Palace at Westminster. The statue, which is of gigantic proportions, is by Marochetti.

Plate Rivets in Iron Steamships.—A writer in a contemporary says:—The awful catastrophe of the loss of the Royal Charter, and her speedy breaking up on the rocks in Moelfra Bay, has recalled to my mind certain discoveries which have of late been made by the officials of her Majesty's Dockyard at Portsmouth in relation to iron vessels, which I think cannot be too widely known, and may possibly have some connection with the speedy breaking up of the Royal Charter. Iron steamvessels have arrived home from foreign stations to a certain extent leaky, and after being paid off and cleared out, have been taken in hand for the necessary repairs. On the insides of the vessel's plates being examined, it has invariably been found that the whole of the rivet heads, wherever the wash of the bilge-water reached, had been worn off as cleanly as if cut by a hammer and chisel. This has led to composition or cement being used over the surface of the plates, of sufficient thickness to raise the surface of the plate to an equality with the head of the rivet; and in some cases bricks have been laid on the top of this cement, thus presenting a smooth surface to the wash of the bilge water, and preventing its action on the rivets. In every case where this has been tried the results have been perfectly successful, the heads of the rivets, after considerable service, being as sound as the first day they were made. On the contrary, where the rivets have not been protected, but left to the action of water and grit, in every case have the heads of the rivets been destroyed, and with nothing to prevent their falling out the first severe strain the vessel should meet with at sea. Her Majesty's troop-ship Megæra, lately returned home from foreign service, is an illustration of what I have stated, and thousands of rivets are now in her bottom, which can be knocked out by a common punch from the inside. The plates of the Royal Charter may have been protected in a manner that would preserve their fastenings, or they may not have been. The fact could very easily be ascertained.

Irish Tramways.—As it is very probable that the bill of Sir Robert Ferguson will become law in the course of the ensuing session of parliament, a prospectus has been issued of the City of Dublin and Suburbs Tramway Company, under the limited liabilities act. A very flourishing account is embodied in the preliminary notice of the success of tramways in New York. It is proposed that the capital of the Dublin company should be £100,000, in £10 shares, to be paid as wanted; to run five lines of 4 miles each through the suburbs, centreing in the business part of the city, and connecting the railways and quays.

Digitized by Google

Casting of the Statue of Mendelssohn.—The colossal statue of the late Mendelssohn Bartholdy, modelled by Mr. Bacon, was cast in bronze on the 22nd ult. at the works of Messrs. Robinson and Cottam, Pimlico. The fidelity of the likeness and the close resemblance of the costume worn by the composer have been much eulogised. The method of casting the statue, which is upwards of 8 feet in height, is peculiar to the establishment of Messrs. Robinson and Cottam, for while it used to be the practice to cast large statues piecemeal, by an improved plan they are now cast entire. The preparations consisted of a large iron case, bound and rivetted together, and built on the floor, of such dimensions as to allow the reception of the full-length figure in a horizontal position. Three furnaces charged with metal poured their contents into a large iron cauldron placed for its reception. This immense cauldron of mixed metal, containing nearly 2 tons, was then raised by machinery, and when immediately over the mould it was tilted into a large receiver, communicating with the mould beneath. A wheel was then turned, and immediately there was a gurgling and gushing of the flaming liquid through about fifty channels, conveying it simultaneously to every part of the horizontal figure beneath. It was interesting to watch the skimming process which went on while the metal was in a state of fusion, so that no unsightly excrescences might appear on the surface of the casting. After the lapse of a few minutes the workmen commenced knocking away the framework and block mould. The work was most successfully performed. The quantity of metal used in the statue is about 1¼ ton: it will stand 8 feet high, and will be elevated on a granite pedestal. Application has been made to the government to allow the statue to be placed in the Mall in St. James's-park.

Mitchell's combined Engine Counter and Clock.—This is an apparatus designed for the purpose of giving an accurate record of the performance of engines and other machinery during any given divisions of time within a given period. This is effected by a suitable arrangement connecting a drum or cylinder covered with paper with the mechanism of the clock, so that it may make one revolution within a given time—so that its revolution will indicate such periods of time, which may be days, or as otherwise may be arranged. A suitable arrangement of mechanism is connected directly to the engine, the speed of which is to be indicated, and which at a given number of revolutions, by means of a style, leaves upon the paper a mark, so that the number of revolutions within the given period of the revolution of the drum is recorded upon the paper, while the gross number of revolutions made is recorded upon an index or counter of the ordinary construction, visible to the engineer. One revolution of the drum may be made to record several days' work, and one cover for the drum may be made to record months of working, as the mechanism can be so arranged that the style may make its recording mark at any given number of revolutions of the engine. This invention is particularly applicable to sea-going steamers. The apparatus is elegant in appearance, the box or case for the mechanism forming a base for the clock.

Steam Navigation on the Amazon.—Mr. Laird, of Birkenhead, has just completed a vessel for a company formed at Rio Janeiro, for the navigation of the river Amazon. This vessel is named the Manhos; she is 225 feet long and 25 feet beam; her tonnage is 681, and she is intended to combine great carrying capacity with speed. She is arranged something on the plan of the American river boats, the decks being carried out to the extreme width of the paddle-boxes, and the whole of the accommodation for first and second class passengers is in large deck houses, leaving the holds entirely free for cargo and coals. Her engines, also constructed by Mr. Laird, are of 180 horse-power nominal, but worked on the trial to between 950 and 1000 indicated horse-power. The paddle-wheels are on the feathering plan, and the boilers are fitted with superheating apparatus and other modern improvements. On two recent trials of her speed and sea-going qualities, between Liverpool and Beaumaris (48 miles), she averaged 16 and 17 miles an hour respectively.

Life-Boat Services.—It appears that during the present year the life-boats of the Royal National Life-boat Institution have, at various points on our coasts, been actively called into operation on fifty-six different occasions. The result has been that one hundred and thirty-four lives have been saved off twenty-three wrecks, besides assisting five vessels safely into port. On twenty-three occasions it happened that when the life-boats had put off in reply to signals of distress, the vessel either got out of danger or the crew was rescued by other means. Again, crews assembled several times to give assistance, but were not required to put off to sea. For these valuable services the crews were paid nearly £600. Nearly all these services took place in stormy weather and heavy seas, and often in the dark hour of the night; and yet not a single accident happened to either of the life-boats or to one of the gallant fellows who had put off in them. On these and on occasions of quarterly exercise, these life-boats were manned probably by no less than 4000 persons. Such practical proofs of the great value of the Royal National Life-boat Institution in a maritime country like ours, cannot possibly be overrated, and it has the highest claims on our support.

Restoration of Melbourne Church, Derbyshire.—This fine old church is now undergoing repair. A short time since the workmen were removing some whitewash from a pillar which supports the lantern tower, when a curious painting of very ancient character was discovered, executed in outline with a kind of red paint. In the upper part of the picture is represented a grotesque portrait of the devil, having horns, wings, talons, &c. The right talon is firmly clutching the shoulder of a figure who is receiving from the hands of a priest either a piece of bread or a small round vessel. In different parts of the picture are some small grotesque-looking figures.

Improvement in the Voltaic Pile.—It is well known that Bunsen's pile, which is a modification of Grove's, consists of a glazed vessel containing a cylindrical element of zinc, which surrounds a porous vessel filled with strong nitric acid, into which a charcoal cylinder has been introduced, the liquid in the outermost vessel consisting of water acidulated with about ten parts of sulphuric acid. Although this is a most powerful combination, and in general use, it has two great inconveniences; first, the quantity of nitrous vapour it evolves is highly unpleasant, and may become dangerous; and, secondly, the current produced is not of constant intensity. M. Thomas has just communicated to the Academy of Sciences a modification which he has effected in this kind of pile, and which would seem to be quite free from the inconvenience alluded to. M. Thomas shows that the development of nitrous vapour is one of the chief causes which interfere with the constancy of the current, inasmuch as they attack the copper ribands forming the electrodes, and effect certain chemical combinations, which give rise to counter-currents, and thus impair the principal one. He therefore causes these gases, as they are evolved, to pass into a porous vessel, where they are decomposed. In this process a secondary current is produced, which, by the peculiar construction of the apparatus, is turned to account, and tends to correct the inequalities of the principal current. This arrangement also prevents the pile from becoming dirty, as is the case with Bunsen's pile.

Revolving Batteries for Coast Defence.—The French papers state that Messrs. Borus and Co. of Nantes, have constructed a great number of gun platforms which are intended for the batteries on the northern and north-western coast of France. These platforms are somewhat similar to railway turn-tables, so that the guns upon the platform may be brought round successively to the desired point, and fired with great rapidity. Mr. Richard Jones, of Hastings, has designed a battery of this kind. It consists of an erection of cast-iron plates of great thickness, bolted or otherwise firmly secured together. The sides are braced by stays to an inner body, consisting of a hollow column, which is used as a shaft for raising ammunition. The whole is to be covered with wrought-iron plates of 2 inches in thickness, between which and the cast-iron plates is a thickness of felt, or other material of a similar nature. The wrought-iron plates are bolted through to the cast-iron plates. The battery is erected upon a solid foundation of masonry, to which it is firmly secured, and resembles in external shape a diver's helmet. The revolving platform is placed about half-way up the building, and there are suitably protected embrasures. The central shaft communicates by means of an underground passage with a powder magazine. This passage has a line of rails, by means of which the ammunition can be run forward on trucks to the central shaft, whence it is raised to the gun-room. The object of forming the battery in this peculiar shape is, that it may throw off shot and shell that may strike it in any line not perpendicular to the resisting surface.

COMPETITIONS.

Designs are required for Baths to be erected at Lytham, on an extensive plot of land, to combine all the requirements desirable for the convenience of visitors at a much frequented watering place. The expenditure not to exceed £5000. Premiums, twenty guineas and ten guineas. The baths are intended to have other public rooms attached to them, which will be explained to any competitor. The proposed site has a frontage of about 170 feet, and comprises an area of 2895 superficial square yards. A plan of the land may be seen, and further information obtained at the Estate Office, Lytham, where designs must be forwarded by the 1st of January next.

Plans are required for the best method of laying out for building purposes, part of the estate of Granton, near Edinburgh, the property of the Duke of Buccleuch, also plans for the different classes of houses to be erected. Premiums, £75, £50, and £25. The plan of the land may be seen, and particulars obtained on personal application to Mr. John Hawkins, Granton Harbour, any day between 11 a.m. and 1 p.m. The conditions of competition will also be obtained from Mr. Hawkins. Competitors to forward their plans with a copy of the conditions, signed, to Messrs. Gibson, H.S., 12, Charlotte-street, Edinburgh, by the 1st March next.

END OF VOLUME XXII.

Digitized by Google

INDEX TO VOL. XXII.

1859.

A

Accrington, Peel institution 54
Adams, on the application of steam to agriculture 58
Adelphi theatre, new 12
Album of Villard de Honnecourt, remarks on, 14
Alderney, breakwater 227
Almanack, companion to (rev.) 34
Aluminum, solder for, 140
American hotel 300
American steam fire engine 312
Amos on waterworks, Trafalgar-square 412
Amazon, steam navigation on the, 416
Antiquity of the human race, Lyell on, 342
Angell, on the life and works of Baldassare Peruzzi 202
Anstey church, Coventry 83
Apsley house, statue of Victory 176
Apethorpe, Roman villa 334
Arcade, opera floral, Covent-garden 211
Architecture, ancient domestic, of Great Britain 380
—— application of natural foliage to, Colling on, 8, 39
—— design in interior, Smirke on, 101, 117
—— gothic ecclesiastical, Bloxam (rev.) 241
—— and genius of Sir Christopher Wren, Wightwick on, 257
—— of the 13th century, Scott on, 83, 125
—— at the London University, lectures on, 352
—— at the Royal Academy 178
—— present state and future prospects of, Tite on, 389
—— of Ireland, ancient 236
—— use of colour in, Smirke on, 143
Architectural association 409
—— congress 248
—— design, theory of proportion in, Lloyd on, 289

Architectural Erections (New)—
Arcade, opera floral, Covent-garden, Barry 211
Chapel, Repton, Stevens 16
—— Royal Dockyard, Woolwich, Scott 56
—— St. Mary and St. Michael, Kensal-green, Nicholl 308
Church, All Saints, Margaret-street, Butterfield 209
—— Cowley, Street 349
—— Greetland, Rushforth 148
—— Greville-place, Kilburn, Habershon 108
—— Hawarden, Flintshire, Scott 249
—— Marazion, Cornwall, St. Aubyn 308
—— Ranmore, Surrey, Scott 385
—— St. Michael and All Angels, Brighton, Bodley 213
—— St. Cuthbert, Hawick, Scott 9
—— St. John, Marchington Woodlands, Gough 381
—— St. John the Baptist, Enfield, St. Aubyn 249
—— St. John, Highbridge, Norton 217
—— Pentrevoelas, Carnarvonshire 74
—— Trinity, Heigham, Smith 381
—— Yiewsley, Middlesex, Scott 269
Cottages, Parndon, Essex, Cooke 388
Gateway, lodge and lich-house, new cemetery, Brighton, Wheeler 177
House, Dawpool, Thurstaston, Walter Scott 313
—— Holloway, Pruefitt 356
Monument, Westminster Crimean, Scott 1

Architectural erections (continued)—
Manufactory and show rooms, Liverpool, Sumners 69
Schools, bluecoat, Coventry, Murray 281
—— and teachers' residences, St. Mary, Islington, Gough 378
Town hall and law courts, Cardiff, Jones 105
Town hall, Halifax, Stevenson 187
Theatre, new Adelphi, Wyatt 12
Vicarage, Fillongley, Murray 1
Villa, Altrincham, Jones 35
Villas, Birmingham, James 141

Architectural exhibition 40, 105, 141, 177, 187
—— museum 176
—— photographic association 11
—— society, Liverpool 402
—— union company 85, 105
Armstrong on high-speed navigation 269
Arsenal and dockyard of Toulon 306
Art gossip, continental 131
Art, promotion of, Mulvaney on, 210
Artesian well, Wolverhampton waterworks, Bateman on, 367
Ashton-under-Lyme new infirmary 140
Associations for the promotion of art, Mulvaney on, 210
Atherton on mercantile steam transport economy 361
Atlantic telegraph cable 221
Atlantic cable 29, 62, 272, 280, 306
Austin on double off-set plotting scale 138
Award of premiums, Inst. C.E. 251
Axle-boxes and coupling rods, Fairbairn on, 61; Brussant on, 170; Curtis on, 205
Aytoun's safety cage for miners 369

B

Barometer as an engineering instrument, Richardson on, 13, 151
Bateman on artesian well at Wolverhampton 367; on Glasgow waterworks 389
Batteries, revolving, for coast defence 416
Baths at Lytham 416
Bell on geometric treatment of sculpture 5
Bell, new Victoria, Leeds town-hall 348
Bells, Westminster-palace clock tower, James on, 411
Belfast new concert-room 312
Bessemer on the manufacture of malleable iron and steel 237
Birmingham, suburban villas 141
Binomial theorem, Cohen on, 227
Binocular vision 60
Blyth breakwater 25, 91, 256
Bloxham on gothic ecclesiastical architecture (rev.) 241
Blakely on constructing cannon 45, 81; on strength of guns and other cylinders 245
Bodies, Wilson on a system of moving 407
Bow on railway chairs and fastenings 174
Bonomi on the Greek canon of the proportions of human figure 56
Boydell's patent traction engine 348
Bourton church, Warwickshire 176
Boilers, Martin vertical water-tube 328
—— horizontal fire-tube, experiments on, 328
—— smoke consuming 120
Brighton, new church of St. Michael and All Angels 213
Brighton cemetery, memorial gateway 177
Brunel, Mr., C.E. 345, 356
Brussels, hotel de ville 140
Brussant on axle-boxes 170
Brakes for railway trains, Fairbairn on, 357
Breakwaters, Blyth 25, 91, 256; Dover, Alderney, Plymouth, and Portland 227
Breakwaters, Murray on, 92, 293; D. and T. Stevenson on, 229
Breakwaters, Abernethy's 254

Bridges—
Westminster new 35, 280
Saltash 103
Sunderland 139
Rhine 146
Railway 280
Victoria (St. Lawrence) 288

Bridges and girders, wrought-iron, Latham on (rev.) 65, 413
British archæological association 312
British museum, additions to, 375
British association 313, 357, 406
Building and sculpture materials in New South Wales 101
Burrell's patent traction engines 347
Burford's panorama galleries 212

C

Cable, Atlantic (rev.) 29, 221, 272, 306, 331
Cable, submarine (rev.) 29, 71, 317; Cox on, 288
Cables, on submerging telegraphic 273, 285
Cables, telegraphic (rev.) 29, 62; Hearder on, 219
Calvert on power of metals to conduct heat 114
Cambridge, new guildhall 312
Cambridge school of practical science, Latham on, 396
Cannon, Blakely on, 45, 81; breech loading 348; new long range 346
Capes on timber framing 76
Carpenter and joiner's assistant (rev.) 122
Cardiff town hall and law courts 105
Carpentry modern, text book of, 31

Cathedrals—
Chester 132
Durham 40
Ely 114
St. Denis, 139
St. Paul's 162
Cologne 248
Hereford 296
Lincoln 348

Cawthorpe, Lincolnshire, new church 248
Cemetery, Brighton 177
Charcoal application of, to the ventilation of sewers 41
Charing-cross railway bill 280
Chappe on experiments on elliptical cast-iron arches 137
Chain propeller, Robertson's patent 408
Chapel, catholic, St. Mary and St. Michael, Kensal-green 308
Chapel, Repton school 16
Chillingworth on direct-acting steam engine 168
Chimney stalk, straightening a, 380

Churches—
All Saints, Margaret-street 209
Anstey, Warwickshire 83
Bourton, Warwickshire 176

Churches (continued)—
City churches 381
Cowley, Oxford 349
Framingham Pigot, Norfolk 342
Greville-place, Edgware-road 108
Greetland, Halifax 148
Hawarden, Flintshire 249
Hougham, Kent 157
Loughborough, Leicestershire 313
Lutton, Lincolnshire 410
Marazion, Cornwall 308
Melbourne, Derbyshire 74
Pentrevoelas, Carnarvonshire 74
Ranmore, Surrey 385
Richmond, Yorkshire 88
Rickinghall Inferior, Suffolk 327
Southwold, Suffolk 381
St. Cuthbert, Hawick 9
St. David, Denbigh 104
St. John, Marchington Woodlands 381
St. John, Highbridge 217
St. John, Glastonbury 3
St. John the Baptist, Enfield 249
St. Michael and All Angels, Brighton 213
St. Michael, Coventry 83
Trinity, Heigham 381
Yiewsley, Middlesex 269

Clarke's system of coal-burning without smoke 370
Clark's process of raising ships 254
Clegg on coal gas (rev.) 376
Clive, statue of Lord 248
Coal, evaporative power of Welsh and Newcastle, &c. 345
Coal-gas, Clegg on (rev.) 376
Coals, mode adopted at South Shields for shipping, 207
Coal-burning without smoke, Clarke on, 370
Coast defence, revolving batteries for, 416
Cockerell on the painting of the ancients 42, 88
Cohen on dynamics 398
Cohen on the binomial theorem 227
Cohen on parallelogram of forces 161
Coinage decimal 248
Coke and coal in locomotives, Fothergill on, 181
Colling on application of natural foliage to architecture 8, 39

Competitions—
Baths, Lytham 416; Cemetery chapel, Over Darwen, Lancashire 348; Granton estate 380, 416; Hartley institution, Southampton 348; Jews' hospital, Mile-end 140; Manchester assize courts 36, 175; Mowle's monument, 36; New guildhall Cambridge 312; New infirmary, Ashton-under-Lyne 140; New concert hall, Belfast 312; Tabernacle, Newington, 36, 69, 139; Training school, Winchester 140

Competitions and awards, list of, 36, 139, 140, 175, 214, 312, 380, 416
Conybeare on the permanent way of railways 354, 393
Continental art gossip 131
Cort and his inventions 250
Cottages at Parndon, Essex 388
Coventry, blue coat schools, Murray 281
Cowley, Oxford, new church, 349
Cox on submergence of telegraph cables 71, 317
Cox, David, monument to 280
Cox's exhibition of pictures &c. 201

Digitized by Google

Crimean monument 13
Cronstadt dock, hydraulic purchase machine for 261
Curtis on axle boxes 205

D

Decimal coinage 248
Decoration, painted, in Southwold church, Suffolk 381
Denison on modern gothic architecture (rev.) 172
Deodorisation of sewage, Hofmann and Frankland on, 325
Docks, Cronstadt 261; Jersey, U. S. 405; Sunderland 139; Tyne 207; Victoria London 205
Dockyard and arsenal of Toulon 306
Domes, construction of, Lewis on, 223
Dover breakwater 227
Drainage works, metropolis 17, 271, 331, 344
Druitt on houses in relation to health 232
Drinking fountains in ancient times and abroad 68
Dry dock, Port Louis, Mauritius 104
Dundee harbour, floating dock gate 108
Durham cathedral 40
Dynamics, Cohen on, 398

E

Earthwork, simple method of calculating, 148, 228, 263
Edinburgh, improvements in, 86
Electrical stratified discharge, Gassiot on, 322
Electric signals, Jenkin on 373
Elliptical cast-iron arches, experiments upon, 137
Ely cathedral 114
Enamelling iron 114
Enfield, St. John the Baptist church 249
Engine counter and clock, Mitchell's 416
Engines, locomotive, axle-boxes and coupling rods for, Fairbairn on, 61
Engines, marine 197
Engines, pumping, cost per horse power, Wicksteed on, 345
Engine shed and turntables, Gateshead station 132
Engine, traction, Boydell's 348
Engine, traction, Burrell's 347
Engineering of North America, Stevenson on (rev.) 253
Engineering, the principles and practice of civil, Coubeare on, 354, 383
Excavations, Wroxeter 346
Exeter college, Oxford 38

Exhibitions—
Architectural 40, 105, 177, 141, 187; building materials 282
Architectural photographic 11
Mr. David Cox's pictures 201
Female artists 168
Fine arts 171
French 160
Photographic 54
Royal academy 178
Werner's water-colour drawings 245

F

Fairbairn on axle-boxes and coupling rods for locomotives 61
Fairbairn on continuous and self-acting railway brakes 357
Fairbairn on density of steam at all temperatures 365
Fairbairn on Henry Cort and his inventions 250
Fillongley vicarage 1
Fire engine, American steam 312
Fitzroy on meteorology 370
Floating dock gate, Dundee harbour 108
Florence, new building 104
Foreign office (new) 2, 75, 386
Fothergill on coke and coal in locomotives 181
Fountains, drinking, in ancient times and abroad 68
Foundations, under-sunk, Spencer on, 304, 387
Framingham Pigot new church, Norfolk 342
Friction, experiments on, Morris on, 9

G

Galleries, architectural (new) 105; Burford's panorama 212; Public 248, 254
Gas in public galleries 248, 254
Garling on contents of album of Villard de Honnecourt 14
Garden, new horticultural, Kensington gore 346
Gassiot on the stratified electrical discharge 322
Gateshead station, locomotive engine shed and turntables at 132
Guage deep-sea pressure, Johnson on, 364
Girders, strength of cast-iron, Lynde on, 386
Glasgow waterworks, Bateman on, 269
Government institutions, photographs for 347
Gradients and curves in America, Isaac on, 23
Granton estate 380
Great Eastern, the 44; moorings of, 280
Greville-place church, Kilburn 108
Greek slave, the 280
Greetland church, Halifax 148
Guns and other cylinders, strength of, Blakely on, 245
Gutta-percha as an insulator at various temperatures, Jenkin on, 321

H

Halifax new town-hall 187
Harbours of refuge 25, 91, 92, 229, 280
Harbour, Dundee 108
Harrison on Tyne docks 207
Haswell on railway switch 53
Hatherleigh-moor, Devonshire, Morris's monument 36
Hamilton on application of quaternions to the geometry of Fresnel's wave-surface 322
Havelock testimonial 36
Hawarden church, Flintshire 249
Hearder on a new form of telegraph cable 219
Heat-diffusers, true action of, Taylor on 361
Heigham, Trinity church 381
Hereford cathedral 296
Holland, great engineering works 104
Hope on common sense of art 50
Hospital, Jews', Mile-end 214
Hospital, new military, Netley 327
Hotel, American 300
Hougham church, Kent 157
House, Middleton-road, Holloway 356
Hull, present state of steam navigation at, Oldham on, 406
Human race, antiquity of, Lyell on, 342
Hume, statue to, 280
Hunt on railway springs 62

I

Ireland, ancient architecture of, 236
Iron, enamelling 104
Iron, experiments on cast 397
Iron and steel, manufacture of, Bessemer on, 237
Iron and steel plates, resistance to shot of, 312
Iron steamships, plate rivets in, 415
Iron ship-building, Taylerson's diagonal principle 332
Isaac on steep gradients and curves in America 23
Islington, new schools and teachers' residences 378

J

Jackson on the water supply for Melbourne 138
James on the bells at the new palace, Westminster 411
Jameson on the performance of the screw steam-ships Sahel and Oasis 97, 133
James on the ordnance survey 233
Jeffries' new long-range cannon 346
Jenkin on gutta-percha as an insulator at various temperatures 321
Jenkin on electric signals 373
Jersey, U. S., dry dock 405
Jews' new hospital, Mile-end 214
Johnson on the deep-sea pressure gauge 364
Johnson on the relative powers of metals and alloys to conduct heat 114

K

Kehl, bridge at 140
Kensal-green, new catholic chapel 308
Kensington-gore, new horticultural garden 346
Kensington museum 312; prizes 176, 312
Kingsbury on Victoria London docks 205
Kremnometer, the 40
Kuhlmann on the use of waterglass in painting and for hardening stone 276

L

Latham on application of the principles of mechanics to wrought-iron girder work (rev.) 63, 413
Latham on the establishment at Cambridge of a school of practical science 396
Lead tubes, tinned 347
Leeds town hall, new bell 348
Lectures at London University on architecture 352
Leicestershire, Loughborough church 313
Leslie on an apparatus for seeing through drains from the surface 331
Lewis on construction of domes 223
Lighthouse illumination, Stevenson on (rev) 189
Lights, unwholesomeness of 104
Lincoln cathedral 348
Literary and philosophical society, Manchester 414
Liverpool architectural society 402
Lloyd on proportion in architectural design and its exemplification in the Parthenon 289
Locomotives, burning Welsh steam coal in 165
Locomotives on common roads 283
Locomotives, coke and coal in, Fothergill on, 181
Locomotive engines, axle-boxes and coupling rods for, Fairbairn on, 61
Locomotive engine shed and turntables, Gateshead 132
London university, lectures on architecture at the 352
Loughborough church, Leicestershire 313
Lutton church, Lincolnshire 410
Lyell on the antiquity of the human race 342
Lytham, baths, 416
Lynch on cast-iron girders 386

M

Machinery, progressive application of, to mining purposes, Taylor on, 277
Mallet on the co-efficients of elasticity and rupture in wrought-iron, &c. 135
Manchester, assize courts 36; literary and philosophical society 414
Marine engines 197
Marchington Woodlands, St. John's church 381
Margaret-street, new church of All Saints 209
Mauritius, dry dock, Port Louis 104
McGrade's method of raising and submerging telegraphic cables 324
McKay on steam engines 239
McMaster on permanent way of Madras railway 170, 204
Melbourne church, Derbyshire 74
Melbourne church, Dorsetshire 416
Mendelssohn's statue 416
Mercantile steam transport economy, Atherton on, 361
Mersey steel and iron works, steam hammer 277
Meteorology, Fitzroy on, 370
Metals and alloys, relative power of, to conduct heat, Calvert and Johnson on, 114

Metropolis—
Buildings 380
Churches 331
Drainage 17, 271
District railway 312
improvements 40, 109, 353
Railway bridges 175
Waters 380
Waterworks, Trafalgar-square 412

Milford-haven, Page on, 402
Mile-end, Jews' hospital 140
Miners' safety cage, Aytoun 369
Mitchell's combined engine counter and clock 416
Montferrand, Chevalier 231

Monuments—
Cox 280
Mozart 104
Stephenson 37
Wallace 176, 346
Westminster Crimean 13

Morris on necessity of further experiments on friction 9
Mozart's monument 104
Mulvaney on associations for promotion of art 210
Murray on breakwaters 92
Murray on an improved cottage window 305
Muswell-hill, palace of the people 99
Museum—British 375; Kensington 312; Southampton 312

N

Navigation, high-speed, Armstrong on, 269
Navigation, steam, on the Amazon 416
Netley, new military hospital 327
New York, new Bowery theatre 376
New South Wales, building and sculpture materials in, 101
Newcastle, proposed Stephenson monument 37
Newington, new tabernacle 36
New theatre Scribe, Turin 104
Notre-Dame, Paris 36, 250

O

Office, foreign (new) 2, 75, 386
Offices, government (new) 249, 386
Oldham, new waterworks 332
Oldham on steam navigation at Hull 406
Opera-house, Rio de Janeiro 346
Ordnance, cast-iron rifled 415
Ordnance survey, James on 233
Oxford, works at Exeter college 38

P

Painted decoration in Southwold church, 381
Painting of the ancients, Cockerell on, 42, 88
Painting, use of waterglass in, Kuhlman on, 276
Palace of the people, Muswell-hill 99
Panama railway 21
Paris, new railway station of the Chemin du Nord 104
Paris, recent improvements in, l'Anson on, 157
Paris on screw vessels 367
Parallelogram of forces, Cohen on, 161
Parndon, new cottages at, 388
Patent laws of England and America 378
Patent laws 323
Patent law for India 176
Patent-office rules 140
Patents relating to ordnance, new laws of, 140

Patents—
Breech loading cannon, Warny 348
Chain propeller, Robertson 408
Hydraulic purchase machine, Miller, 261
New long-range cannon, Jeffries 346
New windlass 344
Railway chair and fastenings, Bow 174
Rettie's submarine lamp 366
Sea wall, Richardson and Jaffrey 415
Self-adjusting spherical bearing, Wallis and Haslam 174
Ship raising machinery, Clark 254
Telegraphic cables, new method of raising and submerging, McGrade 324
Tinning lead tubes, M. Seville 347
Traction engine, Boydell's 348
Traction engine, Burrell 347

Peel institution, Accrington 54
Penn on wood bearings to the shafts of screw steamers 61
Pentrevoelas, new church 74
Penrose on St. Paul's cathedral 162
Peruzzi, life and works of, Angell on, 202
Photographic association, architectural 11, 54
Photographs for government institutions 347
Photographic illustrations for books, Smyth on, 287, 342
Plymouth, breakwater 227
Polytechnic institution 3
Portland, breakwater 227
Power's Greek slave 280
Princess's theatre 212
Public works of the United States 263, 337

Q

Quaternions applied to the geometry of Fresnel's wave surface, Hamilton on, 322

R

Railroads, the superstructure of, Trant wine on, 297

Digitized by Google

Railways—Panama 21; St. Gothard 104; Madras 170, 204
Railways, permanent way of, Conybeare on, 354, 383
Railways, report on, Galton 401
Railway bridge for short spans 280
Railway bridges, metropolitan 175
Railway chair and fastenings 174
Railway springs, a new construction of, Hunt on, 62
Railway station, Chemin du Nord 104
Railway switch, Haswell on, 53
Railway trains, brakes for, Fairbairn on, 367
Ranmore church, Dorking 385
Ransome on soluble silicates 373
Ransome on waterglass and its applications 292
Rawlinson on designs for chimney shafts (rev.) 67
Remains of painted decoration in Southwold church 381
Reports—Milford-haven 402; railways 401; the patent laws 323
Repton memorial chapel 16

Restorations—
Church of St. Mary Tolmers, Hertfordshire 101
Hereford cathedral 296
Hougham church, Kent 157
Loughborough church, Leicestershire 313
Lutton church, Lincolnshire 410
Melbourne church, Derbyshire 74, 416
Notre-Dame, Paris 36, 250
Rickingball Inferior church, Suffolk 327
Richmond church, Yorkshire 88
St. John the Baptist church, Glastonbury 3

Rettie's patent submarine lamp 366

Reviews—
Atlantic cable, Gravatt 29, 62
Application of principles of mechanics to girders, Latham 65, 413
Civil engineering of North America, Stevenson, 253
Carpenter and joiner's assistant 122, 300
Companion to the almanack 34
Designs for chimney shafts, Rawlinson 67
Examples of stained glass, fresco, enamel &c. Waring 377
Grounds of dissatisfaction with modern gothic architecture, Denison 172
Lighthouse illumination, Stevenson 189
Literary and educational year book 174
Manufacture and distribution of coal gas Clegg 376
Mason's bricklayer's, plasterer's, and decorator's guide 243
Principles of gothic and ecclesiastical architecture, Bloxam 241
Recreative science 341
Stones of Etruria and marbles of ancient Rome, Taylor 338
Submarine cable, Airy 29, 62
Telegraphic cables 29, 62
Text book of modern carpentry, Silloway 81
The two paths, Ruskin 251
Year book of facts, Timbs 99

Rickman on metropolitan improvements 109
Richmond church, Yorkshire 88
Richard I., statue of, 415
Richardson on the barometer as an engineering instrument 13, 50
Rio de Janeiro, new opera-house 346
Robertson's patent chain propeller 408
Rome, marbles of ancient, and stones of Etruria, Taylor on, 338
Roman remains 347
Roman villa at Apethorpe 334
Ruskin, the wo paths (rev.) 251

S

St. Cuthbert's church, Hawick 9
St. Denis cathedral 139
St. James's park, new entrance to, 131
St. John the Baptist, Enfield 249
St. John's church Marchington Woodlands 381
St. John the Baptist church, Glastonbury 3
St. John's church, Highbridge 217
St. Lawrence, Victoria bridge 288
St. Michael and All Angels, Brighton 213
St. Michael's church, Coventry 82
St. Mary Tolmers church, Hertfordshire 101
St. Mary and St. Michael's church, Kensal green 308
Saltash, Royal Albert bridge 103
Science and art department, Kensington museum 312
Science, school of practical, at Cambridge 396
Scott on the architecture of the 13th century 83, 125
Scott on breakwaters 25, 91
Scottish society of arts 107
Schools, St. Mary Islington 378; Cambridge 396
Screw propellers 261
Screw steam vessels, wood bearings for shafts of, Penn on, 61
Screw vessels, Paris on, 367
Sculpture, geometric treatment of, Bell on, 5
Sea, reclamation of land from 250
Sea walls and breakwaters 415
Seville's tinned lead tubes 347
Sewers, charcoal for ventilation of, 41
Sewage, deoderization of, 325
Sewage, disinfection of, 344
Sewers for London, purifying 41
Ship-building, Taylerson on, 332
Ship-raising, Clark's patent 254
Ship's windlass 344
Silicates, Ransom on soluble 373
Smirke on design in interior architecture 101, 117
Smirke on the use of colour in architecture 143
Smoke consuming boilers 120
Smyth on photographic illustrations for books 287

Societies—
Architectural association 409
Architectural photographic association 11
Architects, royal institution, award of medals 104, 213
Arts, Scottish society 107
Arts, society of, London, 140, 193
British artists, 147
Engineers, Ireland 29
Engineers, institution of civil 23; general meeting 27; 91, 133, 169, 204, 237, 250, Premiums 251, 411
Literary and philosophical, Manchester 414
Liverpool architectural 402
Photographic 54
Royal Scottish society of arts 308
Surrey archæological 275

Sorby on freezing point of water in tubes 299
Soukssou, Russian steamer 220
Southwold church, Suffolk 381
South Shields, Tyne docks 207
Southampton, Hartley institute 348
Southampton, reading-room and museum 312
Spanish exhibition 248
Spencer on underground foundations 304, 387
Springs, railway, Hunt on, 62
Stained glass, &c., Waring on (rev.) 377
Stark on an improved stove 308
Statics, notes on, Cohen 217
Statue—Clive, Marochetti 248; Havelock, Behnes 36; Joseph Hume, Marshall 280; Mendelssohn 416; Richard I., Marochetti 415; Victory 176
Steam applied to agriculture, Adams on, 58
Steam, density of, Fairbairn on, 365
Steam engine, direct-acting expansive, Chillingworth on, 168
Steam engine, steam jackets in, McKay on, 239
Steamers, destruction of by fire 130
Steam hammer 277
Steam jackets, McKay on, 239
Steam navigation on the Amazon 416
Steam navigation at Hull, Oldham on, 406
Steamships, plate rivets in iron 415
Steam ram and battery, American 36
Steam transport economy, Atherton on, 361
Steep gradients and curves in America, Isaac on, 23
Steel, on the manufacture of Uchatius cast 3
Stephenson monument, Newcastle 37
Stephenson, Mr. Robert 349
Stevenson on breakwaters 229
Stevenson on civil engineering of North America (rev.) 253
Stevenson on lighthouse illumination (rev.) 189
Stone, waterglass for hardening 276
Stove, an improved, Stark on, 308
Straud, improvements in the, 353
Submarine boat 348
Submarine cable (rev.) 29, 62
Submarine lamp, Rettie's patent 366
Submarine telegraphs 208, 272, 273
Submarine telegraph, Bologne and Folkestone 248
Submarine telegraphs, Cox on, 71
Suburban villas, Birmingham 141
Sunderland bridge, reconstruction of, 139
Sunderland new docks 139
Superheated steam 175
Switch, railway, Haswell on, 53

T

Tabernacle, Newington 36, 69, 139
Taylerson on iron shipbuilding 332
Taylor on application of machinery to mining 277
Taylor on the true action of heat diffusers 361
Taylor on stones of Etruria and marbles of ancient Rome (rev.) 338
Telegraph cables (rev.) 29, 62; Hearder on, 219
Telegraph cable, Atlantic 221, 272, 306, 331, 280
Telegraph cables, submergence of, 273, 285; Cox on, 317, 412
Telegraph cables, method of raising and submerging, McGrade on, 324
Telegraphic electricity, Varley on, 149
Telegraph, London district 312
Telegraphs, submarine, Cox on, 71, 208
Text book of modern carpentry (rev.) 81
Theatre—new Adelphi 12; Princess's 212; New York 376
Thomson on submergence of telegraph cables 412
Timbs' year-book of facts (rev.) 99
Timber framing, Capes on, 75
Tite on progress and present state of architecture 389
Tomlinson on Welsh steam coal in locomotives 165
Town-hall, Leeds 348; Halifax 187
Trafalgar-square, waterworks, Amos on, 412
Tramways, Irish 415
Trautwine on superstructure of railroads 297
Tubular drains, Leslie on, 331
Turin, new theatre Scribe 104

U

Uchatius cast steel, manufacture of, 3
University, London, lectures on architecture at, 352
United States, dry dock, Jersey 405
United States, public works of, 263, 337

V

Varley on telegraphic electricity 149
Ventilation, Rettie's patent submarine lamp 366
Vessels, raising sunken 236
Villard de Honnecourt's album, remarks on 14
Villa, Roman at Apethorpe 334
Victoria (St. Lawrence) bridge 288
Voltaic pile, improvement in, 416

W

Warny's breech loading cannon 348
Waring on stained glass, fresco ornament &c. (rev) 377
Wallace monument 176, 346
Water, freezing point in capillary tubes, Sorby on, 299
Water supply for Melbourne, Jackson on, 138
Water-works Glasgow 369; at Oldham 332; Trafalgar-square 412; Wolverhampton 367
Waterglass, use of, Kuhlmann on, 276
Waterglass and its properties 215, 264
Waterglass, its application to the arts, Ransome on, 292
Weights and measures, universal system of 379
Werner's water-colour drawings 245
Westminster, hanging the bells at the new palace, James on, 411
Westminster bridge, new 35, 280
Wightwick on architecture and genius of Sir Christopher Wren 259
Wilson on a system of moving bodies 407
Winchester training school 140
Window, an improved cottage, Murray on 305
Windlass, new ship's 344
Wivenhoe church, Essex 248
Wolverhampton waterworks, artesian well, Bateman on, 397
Wood bearings for shafts of screw steamers, Penn on, 61
Woolwich, new chapel, royal dockyard 56
Wren, works and genius of, Wightwick on, 257
Wroxeter excavations 346
Wrought-iron, coefficients of elasticity and rupture in, Mallet on, 135
Wrought-iron bridges, Latham on (rev.) 65, 413
Wrought-iron and steel, experiments by Napier and Sons 317
Wyatt on Panama railway 21

Y

Year-book of facts, Timbs' (rev.) 99
Yiewsley new church, Middlesex 269

Digitized by Google

LIST OF ILLUSTRATIONS.

Apparatus for experiments on density of steam, Fairbairn 366
Apparatus for seeing through tubular drains, Leslie 331
Apparatus for raising and submerging telegraphic cables, M'Grade 324
Barnack church tower, Northamptonshire 242
Breakwater, Abernethy 255
Breakwater, Stevenson 250
Bread making machine 195
Cannon 45, 46, 47, 48
Chancel window, Chartham, Kent 242
Circular window, Leek church, Staffordshire 248
Coal-burning locomotive fire-box, Clarke 370
Compensation bars (surveying) 233
Cottage window, Murray 305
Crypt, Canterbury cathedral 243
Kremnometer, the 40
Lattice bridge, Town's patent 253
Lattice trusses 300
Life-boat and carriage of the Royal National Life-boat Institution 247
Lighthouse illumination 189, 190, 191, 192, 193
Metallic spring piston, Parkin 194

PLANS—
Chapel, Repton school 16
Chapel, Kensal-green 308
Church, Greetland 148
Church, Marazion 308
House, Dawpool, Cheshire 313
House, Middleton-road, Holloway 356
School, Bluecoat, Coventry 281
Vicarage, Fillongley 1
Villa, Altrincham 35
Villas, Birmingham 141

Refraction protractor, Balfour 310, 311
Roman tower, Dover Castle 241
Railway chair and fastenings, Bow 174
Railway switch 53
Roman remains 339, 340
Roof of nave, Adderbury church 242
Ruined church, Dover Castle 241
Self-adjusting spherical bearing, Wallis and Haslam 175
Spirit level, Bow 108
Sepulchral cross, Bakewell, Derbyshire 243
Steam pressure gauge, Mann 194
Stove, Stark 309
Superstructure of railroads, Trautwine 297
Telegraphy 149, 150, 151, 152
Undersunk foundations 305, 387

LIST OF PLATE ENGRAVINGS.

Plate		Opposite page
1.	Fillongley Vicarage, Warwickshire	1
2.	Memorial Chapel, Repton School	16
3.	Villa, Altrincham, Cheshire	35
4.	New Chapel, Royal Dockyard, Woolwich	56
5.	Wood Bearings, as applied to shafts of screw steamers; Axle-boxes and Coupling Rods for Locomotives; New Construction of Railway Springs	61
6.	Manufactory and Show Rooms, Liverpool	69
7.	Examples of Timber Framing	76
8.	Church of St. Mary Tolmers, Herts	101
9.	The Town Hall and Law Courts, St. Mary-street, Cardiff	105
10.	Ground Plan ditto ditto	
11.	Church, Greville-place, Edgware-road, Kilburn	108
12.	Locomotive Engine Shed and Turn-tables at Gateshead station	132
13.	Suburban Villas, Birmingham	141
13a.	ditto ditto	
14.	Greetland Church, Halifax, Yorkshire	148
15.	Hougham Church, Kent	157
16.	Fire Box of Coal-burning Locomotive Engine; Direct-Acting Expansive Steam Engine	165
17.	Memorial Gateway, Lodge and Lich House, New Cemetery, Brighton	177
18.	Church of St. Michael and All Angels, Brighton	213
19.	Breakwaters—Alderney, Dover, Plymouth and Portland	229
20.	Church of St. John the Baptist, Enfield, Middlesex	249
21.	Breakwater at Blyth	256
22.	Water Balance Machine at Dowlais Iron Works, Wales; Struvé's Mine Ventilator	277
23.	Bluecoat School, Coventry	281
24.	Construction of Breakwaters	293
25.	St. Mary and St. Michael's Chapel, Catholic Cemetery, Kensal Green; New Church, Marazion, Cornwall	308
26.	Dawpool House, Cheshire	313
27.	Taylerson's Diagonal Principle of Iron Shipbuilding	332
28.	New Church at Cowley, near Oxford	349
29.	House, Middleton-road, Holloway	356
30.	St. John's Church, Marchington Woodlands, Staffordshire; Trinity Church, Heigham, Norwich	301
31.	Cottages at Parndon, Essex	388

Digitized by Google

Digitized by Google

Digitized by Google

Fiske Kimball
PLEASE RETURN TO
FINE ARTS LIBRARY
THE ENGINEERING LIBRARY

Fiske Kimball
FINE ARTS LIBRARY

NON-CIRCULATING

RX 002 129 456

Digitized by Google

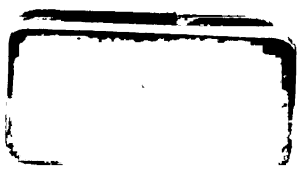
Digitized by Google

Fiske Kimball
PLEASE RETURN TO
THE ENGINEERING LIBRARY
FINE ARTS LIBRARY

Fiske Kimball
FINE ARTS LIBRARY

NON-CIRCULATING

RX 002 129 456



Digitized by Google

Digitized by Google